PROJECT REPORT

Fall River 2005 Macroinvertebrate and Channel Cross Section Monitoring

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INTRODUCTION

The Fall River in Shasta County, CA, is experiencing high rates of sedimentation, growth of invasive aquatic weeds. Potential negative impacts of these stressors on the macroinvertebrate community could limit resources available to rainbow trout and other fishes in the Fall River and potentially lead to a reduction in aquatic resources available to migratory waterfowl, shorebirds, and other wildlife that utilize Fall River. Sediment deposition can negatively impact benthic invertebrates by clogging interstitial spaces and interfering with gas exchange (Cooper 1987). In fact, there has been a purported decline in hatches of aquatic invertebrates. Sedimentation and invasive weeds can also negatively impact native vegetation. Invasive aquatic plants such as the Eurasian milfoil (*Myriophyllum spicatum*) can outcompete native plants such as horned pondweed (*Zannichellia spp.* referred to locally as Z-grass), especially in areas where native plants may already be impacted by disturbances like sedimentation. Even when non-native plants appear similar in structure or function to native plants, they may have different rates of oxygen exchange which will influence the type and abundance of macroinvertebrates present as well as the foraging capability of fish (reference?). Eurasian milfoil had been shown to support lower invertebrate densities and biomass than other native macrophytes (Cheruvelil et al. 2001).

Managing these potential stressors may require manipulation of the system, a course of action that is difficult to take without specific knowledge of the aquatic plant and invertebrate communities in Fall River. Current knowledge of the Fall River aquatic plant and invertebrate communities is based on casual observations of local residents and two previous

studies. For example, the fishing community in Fall River watershed has reported large emergences of the "spinner" *Hexagenia,* a burrowing mayfly. Members of *Hexagenia* are often considered aquatic keystone species within the food web because they obtain energy sources from detritus (bottom litter) and are in turn eaten by many different fish (USGS Great Lakes Report).

The California Department of Water Resources (DWR) initiated a study to examine sediment deposition and the resulting impacts to Fall River invertebrates in the fall of 1996 and spring of 1997. The study was initially designed to be a long term monitoring effort, but due to a lack of funding the project ceased after one year. The DWR collected aquatic macroinvertebrates from Spring Creek and the Fall River using a Ponar grab sampling dredge, and their collections did not reveal *Hexagenia* populations. The DWR report suggested that future monitoring was needed to determine the impacts of sedimentation on macroinvertebrate communities, and to examine the differences in macroinvertebrates found in native and non-native aquatic vegetation (DWR 1998). A study contracted by the Fall River Resource Conservation District (FRRCD) and conducted in 1998 and 2000 by SHN Consulting Engineers and Geologists of Redding, California, examined total invertebrate abundance and total abundances of Oligochaeta, Chironomidae, Ephemeroptera, Plecoptera and Trichopetera in the Fall River. The SHN study was designed to provide baseline information necessary to complete a demonstration dredging project. However, the FRRCD decided to cancel the project due to improved aquatic vegetation growth in the project area (SHN 2002). A need for further characterization of the aquatic macroinvertebrate community was established.

The Aquatic Ecosystems Analysis Laboratory (AEAL) at the University of California, Davis, was contracted by the FRRCD to establish eight physical channel cross-sections throughout the Fall River system to append an existing water quality monitoring program with physical cross sections and macroinvertebrate monitoring. Ponar grab bottom dredge samples were conducted by the AEAL in November 2005 at each of the eight channel cross-section survey sites. Three of the cross-section sites used existing transects set up in the 1996/1997 DWR study. The remaining five sites were located near transects used in the DWR and SHN studies. Permanent survey monuments were established at each cross-section to allow for repetition of sampling efforts.

In addition to sediment sampling of invertebrates, four types of aquatic vegetation were collected as part of a preliminary study to 1) determine differences between macroinvertebrate communities in native and nonnative vegetation, and 2) explore aquatic vegetation sampling methodology for macroinvertebrates in the Fall River. Four aquatic weeds were analyzed for macroinvertebrate contents: Eurasian watermilfoil (*Myriophyllum spicatum*), Northern watermilfoil (*Myriophyllum sibiricum*), Chara (*Chara spp.*), and Z-grass (*Zannichellia spp.)*. Eurasian milfoil and Northern milfoil are referenced as E milfoil and No milfoil, respectively, in the tables of this report. Northern milfoil and Z-grass are considered to be native to the Fall River (C. Pirosko, personal communication, November 2005).

Objectives

- Establish eight channel cross-sections throughout the Fall River system; survey the physical characteristics of each cross-section; install permanent survey monuments at each cross section; survey elevations for all cross-section monuments.
- Conduct Ponar grab dredge sediment sampling for invertebrates along 8 channel cross-sections. Calculate diversity metrics, taxa richness, and describe dominant taxa present in those samples.
- Collect three samples in each of the four aquatic weeds. Calculate diversity metrics, taxa richness, and describe dominant taxa present in each species of weed.
- Calculate number of invertebrates present per gram of vegetation for each of the aquatic weed species sampled.
- Calculate number of invertebrates per square foot for each of the channel cross sections.
- Compare results of study to previous studies preformed along comparable channel cross sections.
- Explore aquatic plant sampling methodology for collection of macroinvertebrates. Make suggestions for future studies regarding macrophytes and invertebrates along Fall River.
- Report differences in and compare metrics and abundances of macroinvertebrates among different habitats (sediment and vegetation).

MATERIALS AND METHODS

Site Selection

Eight channel cross sections and nine vegetation sites were surveyed and/or sampled between November 7, 2005 and November 11, 2005 (Table 1). A handheld Garmin eTrex GPS unit was used to mark the coordinates of each site (Figure 1).

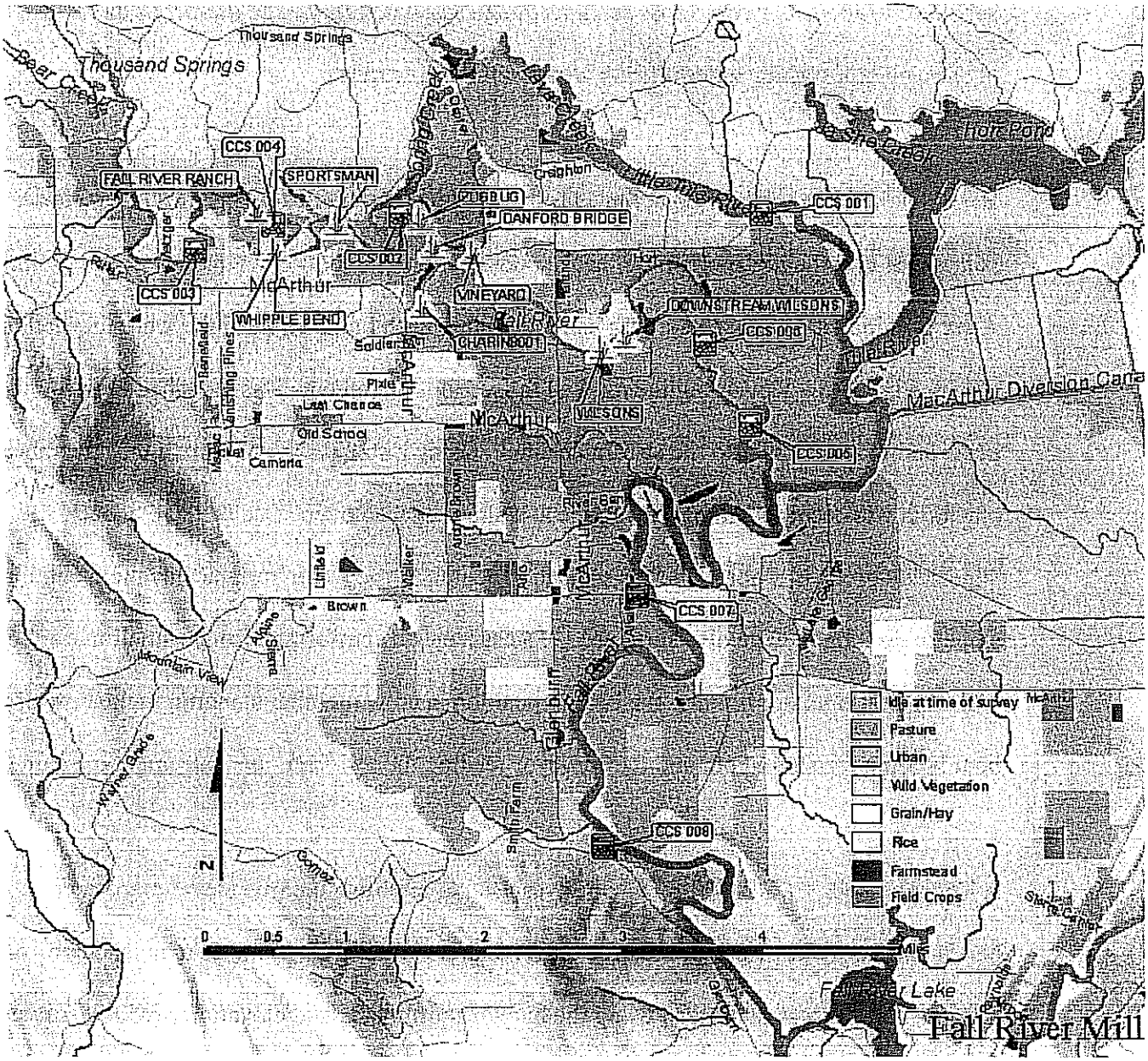
Channel cross sections (CCS001- CCS008) were selected in the upper, middle and lower sections of the Fall River system to create reference sites that could be monitored for changes in sedimentation. Three of the channel cross sections (CCS002-CCS004) had been established in a 1996-97 study by the California Department of Water Resources.

The nine vegetation sites were chosen on the basis of their proximity to the channel cross sections and to each other. The distribution of vegetation in the sections of the Fall River was found to be patchy, and vegetation sites were chosen based on the presence of a specific macrophytes of interest (Z-grass and Northern milfoil were present in fewer locations). Multiple macrophyte species were found in the Fall River and Little Tule River including Elodea, Sago, Z-grass, Callitriche, tules, Eurasian milfoil, Northern milfoil, Ranunculus, and Chara. Northern milfoil and Z-grass were selected because they were the most common native plants. Eurasian milfoil occurred in most sections of the stream with the exception of sites that contained Northern milfoil, and was chosen because it was the most pervasive nonnative plant. Chara was chosen as a second nonnative vegetation because high abundances (Table 1).

Table 1. Site locations and description.

SITE ID	SITE DESCRIPTION	LATITUDE (N)	LONGITUDE (W)	AQUATIC VEGETATION PRESENT AT SITE
CCS001	Little Tule River below Eastman Lake	41.10142	121.46354	Elodea, Sago, Z-grass
CCS002	Downstream of Spring Creek Bridge	41.10196	121.51344	Elodea, Z-grass
CCS003	Thomas Ryan Allotment	41.09867	121.54179	Elodea, Callitriche
CCS004	Gasline (Fall River Ranch)	41.10120	121.53096	Elodea, Ranunculus
CCS005	Downstream Lakey Ranch	41.07940	121.46574	Eurasian milfoil, Elodea, Tules
CCS006	Upstream Lakey Ranch	41.08787	121.47170	Tules
CCS007	Owl's Head	41.06152	121.48196	Eurasian milfoil, Elodea
CCS008	Upstream River Ranch Bridge	41.03511	121.48744	Elodea, Eurasian milfoil
CHARINB001	Above first bridge upstream of Island Road Bridge	41.09235	121.51072	Eurasian milfoil, Elodea, Chara, unknown species
Danford Bridge	50 m upstream of Danford Bridge	41.09861	121.50903	Z-grass, Eurasian milfoil, Chara
Fall River Ranch	Fall River Ranch	41.10277	121.53316	Northern milfoil
Sportsman	Sportsman	41.10109	121.52220	Northern milfoil
Vineyard	Vineyard	41.09777	121.50363	Eurasian milfoil, Z-grass
Whipple Bend	Whipple Bend	41.09854	121.53078	Northern milfoil
Wilson's	Wilson's	41.08761	121.48604	Eurasian milfoil, Z-grass
Downstream Wilson's	0.8 mile downstream Wilson's	Not taken	Not taken	Z-grass, Eurasian milfoil, Chara
Zugbug	near CCS002	41.10155	121.51067	Z-grass

Figure 1. Map of Fall River sampling sites and channel cross sections.



Channel Cross-Section Survey Methods

Between November 7 and December 21, 2005 five channel cross sections were established and surveyed, and three previously existing channel cross sections were re-surveyed, throughout the upper, middle and lower reaches of the Fall River watershed. The cross sections are used to enable repeated measurements over several years in order to record changes and rate of change in channel morphometry due to sediment movement. Establishing

accurate elevations for each cross section allows for measurement of changes in water surface elevations between cross sections due to seasonal bloom and die-off of the invasive aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*).

Benchmarks were established at the ends of each cross-section using plastic survey stakes hammered into the highest point of each stream bank until about 3" remained above ground. A six foot long steel fence post was hammered into each bank between the waterline and the survey stake and a Kevlar tagline marked in five foot increments was stretched between the posts and perpendicular to the stream channel. Using a stadia rod and transit the streambed elevation was recorded along the tagline at stations spaced every five feet and at each significant break in slope. The top of each benchmark, the water surface elevation, and the slope of each bank were also surveyed. The survey was performed from a small motor boat with the boat operator holding the boat in position, a crew member standing in the bow of the boat holding the stadia rod, and the surveyor reading the rod from the instrument on shore.

A Topcon Hiper + / GB-500 RTK GPS was used to establish the true elevation of each benchmark to within 0.01' of mean sea level and the lat-long coordinates to an accuracy of ≤ 0.10'. The GPS was calibrated using the known coordinates and elevation of USGS survey monument MW0481 located in front of the old F.L. Whipple ranch house on Spring Creek Road near the intersection with McArthur Road in Shasta County, CA. The horizontal and vertical positions for MW0481 were adjusted by the USGS using North American Datum 83 (NAD 83) and North American Vertical Datum 88 (NAVD 88). Data for this monument was obtained from the National Geodetic Survey website: http://www.ngs.noaa.gov/ . The maximum range of communication between the GPS base station and its receiver was

approximately 1.2 miles. For some cross sections this required surveying up to three turning points to reach from the USGS monument to the cross section benchmarks.

Channel Cross Sections

Background

A 1983 Fall River Watershed Area Study by the USDA River Basin Planning Staff found that soil erosion and siltation rates in the Fall River watershed were "not a serious problem" and "are generally low and may not be much in excess of natural geologic erosion" (USDA 1983). Since that time there has been a significant increase in the rate of siltation which can most likely be attributed to erosion caused by a large fire in the Fall River headwaters, and by the incising of a channel through the meadow that the Bear River historically flowed through before entering the Fall River (C. Pirosko, pers. comm). The large volume of sediment in the river has caused concern among resource managers, property owners, fishermen, and other users and has led to several studies of the problem.

In 1994 the Fall River Wild Trout Foundation (FRWTF) established and surveyed 20 channel cross sections throughout the Fall River system to monitor sediment deposition (Fitzwater 1994).

In 1996 the California Department of Water Resources (DWR) established 24 monitoring stations throughout the Fall River system to monitor sediment transport and the affects on macroinvertebrate and plant communities. Cross Section surveys were completed at 12 of the monitoring stations (DWR 1998). They found that nine of the cross sections experienced

net gain in sediment and the remaining three cross sections experienced net loss of sediment. There was some overlap in cross section locations between the FRWTF and DWR surveys although there is no record to indicate to what extent DWR was able to replicate the FWRTF cross sections. DWR established permanent survey monuments at each of their cross sections using steel posts with brass caps placed in cement. The position of each monument was established using a fast-static GPS survey.

In 1998 the consulting firm Tetra Tech was contracted by the Fall River Resources Conservation District (FRRCD) to develop an analysis of sedimentation and an action plan for the upper Fall River. They used DWR data to reconstruct each of the DWR cross sections and measure the accumulations of both newer (softer) and older (harder) sediment over the historical streambed which mainly consisted of diatomaceous earth, clay, hardpan, and lava cobbles (Tetra Tech 1998).

In 2001 the environmental consulting firm SHN, from Redding, California was contracted by the FRRCD to monitor the effects of a demonstration dredging project in the Fall River in response to recommendations made in the Tetra Tech report. The demonstration dredging project was never implemented. However, SHN did re-survey several of the DWR cross sections prior to cancellation of the dredging project. In this study we compare the results of our cross section surveys with those performed by the FRWTF, DWR, Tetra Tech and SHN.

Three of our eight cross sections replicate cross sections from the DWR surveys: Spring Creek (CCS002), Thomas Ryan Allotment (CCS003) and Fall River Ranch (CCS004). Table

3 provides the three cross sections that we replicated and that were also surveyed by the FRWTF, Tetra Tech and SHN.

Method for Measuring Physical Changes in Channel Cross Sections

A net gain or loss of sediment between surveys was calculated for each of the replicate cross sections by comparing the channel cross section area between surveys. This was accomplished by overlaying the cross sectional profiles from two surveys of the same site onto a grid, and calculating the difference in area between the two sections.

Because no tables of measurements, or any raw data, were available for the FRWTF, DWR, Tetra Tech and SHN cross sections we had to interpolate from the graphs contained in the reports issued by those groups. Appendix VII contains cross sections CCS002-CCS004 with the identical cross sections from the FRWTF, DWR, Tetra Tech and SHN surveys and summaries of the net change in sediment between surveys.

Benchmarks were established at the ends of each cross-section by driving a survey stake into the highest point of each stream bank until about 3" remained above ground. The true elevation of each benchmark was established to within 0.01' of MSL using a Topcon Hiper + / GB-500 RTK GPS. The GPS was also used to survey the latitude and longitude of each benchmark to an accuracy of ≤ 0.10'. The GPS was calibrated using known coordinates and elevation of the USGS survey monument MW0481 located in front of the old F.L. Whipple ranch house on Spring Creek Road near the intersection with McArthur Road in Shasta County, CA. The horizontal and vertical positions for MW0481 were adjusted by the USGS using North American Datum 83 (NAD 83) and North American Vertical Datum 88 (NAVD

88). Data for this monument was obtained from the National Geodetic Survey website: http://www.ngs.noaa.gov/. The maximum range of communication between the GPS base station and its receiver was approximately 1.2 miles. For some cross sections this required surveying up to three turning points to reach the USGS monument from the cross section benchmarks.

A six foot long steel fence post was hammered into each bank between the waterline and the survey stake, and a Kevlar tagline marked in five foot increments was stretched between the posts and perpendicular to the stream channel (Table 2). Using a stadia rod and transit the streambed elevation was recorded along the tagline at stations spaced every five feet, and at each significant break in slope. The top of each benchmark, the water surface elevation, and the slope of each bank were also surveyed. The survey was performed from a small motor boat with the boat operator holding the boat in position, a second crew member standing in the bow of the boat holding the stadia rod, and the surveyor reading the rod from the instrument on shore.

Table 2. Fall River cross sections, benchmark locations and elevations, November 2005.

Cross Section	Site Name	Latitude of Left BM	Longitude Of Left BM	Right BM Elevation (ft)	Left BM Elevation (ft)
CCS001	Little Tule River	41.10161	-121.48281	3307.27	3306.61
CCS002	Spring Creek	41.06071	-121.30481	3312.85	3311.18
CCS003[1]	Thomas Ryan Allotment	41.09640	-121.53088	3313.24	3316.21
CCS004	Fall River Ranch	41.06042	-121.31513	3313.33	3314.00
CCS005	Lakey Ranch Downstream	41.08532	-121.48330	3308.05	3311.51
CCS006	Lakey Ranch Upstream	41.09242	-121.48942	3308.07	3309.45
CCS007	Owl's Head	41.03424	-121.28501	3313.00	3310.18
CCS008	River Ranch	41.02100	-121.29106	3306.89	3317.58

[1]The coordinates listed for CCS003 are for the right benchmark. We were unable to cross the river to the left bank at this site during our GPS survey. The left benchmark elevation was calculated using the right benchmark elevation and the cross section survey data.

Sample Collection and Processing

Sediment was collected by taking Ponar grab samples from a motor boat using a standard Ponar grab/ Ponar dredge sampler with a scoop volume of 8200 mL and a sample area of 229 x 229 mm (9" x 9"). Ponar grabs were taken along each of the eight channel cross-section transects. Four or five grabs were taken per transect, depending on width, and combined into one sample. The grabs were spaced evenly across each transect while avoiding areas of dense vegetation that prevented proper functioning of the sampler. If the sampler did not close completely the sample was discarded and a new sample collected. To reduce sorting time each Ponar grab sample was elutriated in the field using a 500ml squeeze bottle and clean river water. Ponar grabs that contained more than 50% vegetative material were discarded. Ponar grab samples were preserved in 95% ethanol and rinsed through a standard

U.S. #30 Tyler sieve to replicate the efforts of the DWR study. Samples were placed in a grid were randomly sub-sampled to reach 300 individuals. Sorted samples were stored in 70% ethanol.

Table 3. Location and elevations of each cross section monument.

UCD Cross Section	Site Name	DWR Cross Section	SHN Cross Section	Tetra Tech Cross Section	FRWTF Cross Section
CCS002	Spring Creek	21	21	21	??
CCS003	Thomas Ryan Allotment	9	9	??	9
CCS004	Fall River Ranch	NA	15b	NA	NA

Samples of aquatic vegetation were collected from a boat using a modified aquatic weed rake on an extension pole. The rake was swept through a bed of vegetation by one sampler while a second sampler followed immediately behind with a D-frame dip net (500 μm mesh, 0.3 m by 0.3 m net dimensions). Three weed rake grabs were combined to create a single vegetation sample per site. The plants were placed in a bucket and water from the bucket was rinsed through a 500 μm mesh sieve to collect any invertebrates loosened from the plant material. The plants and all sieved invertebrates were then placed in a Ziploc bag, labeled and placed on ice in a cooler. The weed rake methodology was employed by the AEAL to calculate the number of invertebrates per wet weight and dry weight of plant material. Toft et al. 2003 employed a similar method that involved manually collecting aquatic

macrophytes for epiphytic invertebrates and then immediately placing the macrophytes into a bucket prior to further processing. Other methodologies of collecting macroinvertebrates from aquatic vegetation such as hoop nets/mesh bags (Cherurvelil 2000), core samplers (Kornijów 2005), and Downing box samplers (Strayer et al. 2003) would have required the use of scuba equipment due to the depth of vegetation in the Fall River.

During a preliminary scouting trip in October 2005 it was noted that Z-grass samples collected with the weed rake method appeared to have noticeably different invertebrate abundances than Z-grass samples collected by sweeping a D-frame dip net through the vegetation. These differences did not appear when sampling milfoil and Chara. Because Z-grass has a different plant structure (linear leaves) than milfoil and Chara (whorled filaments and dissected leaf segments) it is possible that the whorled filaments and dissected leaf segments prevent the invertebrates from dropping off the plants as readily as they do from the linear leaves of Z-grass. To ensure successful invertebrate sampling of the Z-grass we collected additional Z-grass samples by aggressively sweeping the D-frame dip net five times in succession through the vegetation, placing the collected vegetation in a bucket and repeating the process twice more. The results of the three efforts were then combined into a single Z-grass sweep sample, placed in a Ziploc bag, labeled and stored on ice in a cooler.

Vegetation samples were kept on ice until arrival at the AEAL and transferred to a refrigerator until processing. All vegetation samples were processed within one week of collection to minimize degradation (samples were not preserved in alcohol). Aquatic vegetation samples were rinsed through a U.S. #30 Tyler sieve and processed in the same manner as the Ponar grab samples to obtain a maximum of 300 invertebrates. Once

processed, sorted plant material was refrigerated until all plant samples had been processed (to ensure that all plants were degraded to the same degree). Samples were weighed on an Ohaus Navigator scale accurate to 1/100g. Vegetation samples were then dried in an oven at 69°F for 48 hours and re-weighed. Sorted macroinvertebrate samples were preserved in 70% ethanol and identified to the same taxonomic level as was used to identify the invertebrates collected in the Ponar grab samples.

Physical Parameters

Water temperature, pH, conductivity, and dissolved oxygen were measured at the mid-point of each channel cross section during invertebrate sampling (Table 3). Dissolved oxygen was measured with a Traceable digital dissolved oxygen meter. All other water chemistry parameters were taken using an Oakton pH/Con 10 multiparameter meter. The dissolved oxygen meter was calibrated before each use, and the Oakton ph/Con 10 multiparameter meter was calibrated once at then beginning of the sampling period according to the standard operating procedures for the meters (Appendices V-VI). GPS coordinates were taken using a Garmin etrex handheld unit.

Sample Identification and Metric Calculations

Specimens were identified to the following levels: chironomids were identified to subfamily, oligochaetes were identified to class, and all other invertebrates were identified to the lowest taxonomic level reasonably possible. Specimens in poor condition and those at very young instars (lower than the 5th instar) were left identified to the next highest taxonomic level. Macroinvertebrates were identified to the California Stream Bioassessment Procedure Level

II (CSBP-II) standard (CAMLnet, 2003) using Merritt and Cummins (1996), Pennak (Smith 2001), and Thorp and Covich (2000), as well as taxon group-specific references. External Quality Control (QC) of identifications of two Ponar grab samples and two vegetation samples as well as identification of difficult taxa, was performed by the California Department of Fish and Game's Aquatic Bioassessment Laboratory (CDFG ABL) in Chico. Samples examined by the CDFG ABL composed almost 20% of all materials processed and identified. The acceptable error level in identification and counting of invertebrates was less than 10%. All samples passed external QC (Table 4). Any taxa misidentified in the samples sent to the CDFG ABL were reexamined in that sample and in all samples were that taxa occurred. Any taxa in which there was a discrepancy or uncertainty in identification were recorded at a higher classification level.

Table 4. External QC results for macroinvertebrates collected and identified during the project.

Sample Name/ Date	Type	Pass/Fail[1]	% Taxa Misidentified
Wilson 10-XI-2005	Vegetative	PASS	4.35%
Fall River Ranch Br 09-XI-2005	Vegetative	PASS	4.17%
CCS007 11-XI-2005	Ponar	PASS	3.45%
CCS002 08-XI-2005	Ponar	PASS	7.41%

[1]Criteria for passing is based on having less than a 10% misidentification rate during the external QC checks.

Abundances of different taxa were entered into CalEDAS version 3.0.1, California's state bioassessment modified Microsoft Access database. The samples varied in the number of

invertebrates they contained and in some cases they had to be condensed to make the samples comparable to each other. The reduction of total invertebrate abundances was achieved by randomly re-sub-sampling any samples with greater than 300 invertebrates to 300 invertebrates total using the Monte Carlo function in the CalEDAS database. The percentage of individuals in a specific taxon was used in the analyses instead of total number of individuals or number of individuals per square foot (or square meter) to allow comparison of vegetation samples to Ponar samples and to allow for comparison with samples that had less than 300 individuals. Taxa abundance lists and metrics such as taxa richness, percent Oligochaete individuals, percent EPT (Ephemeroptera, Plecoptera, and Trichoptera) individuals, and percent Chironomidae individuals (where percent taxa individuals equals the number of individuals per a specific taxa divided by the total number of individuals per sample) were calculated using the Report function in CalEDAS. Metrics were chosen on the basis of their use in previous Fall River studies. All database entries were double-checked by an independent reviewer for accuracy.

In this study, the observed diversity of each sample was compared to the maximum possible diversity for that sample by calculating a measure of evenness. The evenness score determines whether or not the species present are equally abundant, with a score of 1.0 designating that all species present were equally represented. We used the Shannon diversity index (metric) which factors evenness into the equation. However, a high Shannon diversity score can indicate that the sample has a large number of unique taxa (the sample has high taxonomic richness) and/or that a sample has a high evenness score. Shannon diversity was calculated in CalEDAS.

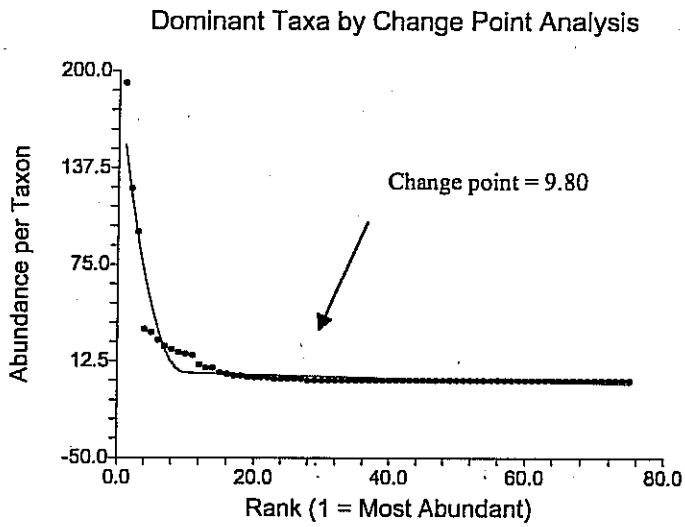
Evenness scores were calculated when it became apparent that the distribution of invertebrates was different between samples that contained similar numbers of unique taxa. Internal QC checks were performed on diversity and evenness calculations for ten percent of all samples. The internal QC revealed that CalEDAS had failed to perform the Shannon diversity calculations correctly for more than ten percent of samples. Shannon diversity indices and evenness scores were then recalculated from the taxa abundances using Microsoft Excel®. Internal QC was performed on ten percent of all Excel based calculations.

Dominant Taxa and Statistical Analyses

Dominant taxa are usually categorized by rank (a specific number of the top taxa) or by including taxa that comprise a percent abundance of the total sample. Because it was unclear which method was employed by the 1996/1997 DWR study, we employed a culling method that combined these techniques. Dominant taxa were determined through a piecewise-polynomial curve fitting analysis (change point analysis) of the total counts of taxa collected. Dominant taxa were calculated for all Fall River samples, all vegetation samples, all Ponar samples, each channel cross section, for specific vegetation rake samples, and for Z-grass sweep samples. When determining the dominant taxa by vegetation type, all taxonomic data from the same vegetation sampling method (e.g. rake, D-net sweep) were combined to produce a total counts-per-taxon list. We then ranked the taxa by abundance in descending order, producing a function where rank is the x-axis and abundance the y-axis. Next, curve fitting analysis in NCSS Number Cruncher Statistical Software (Hintze 2000) computed the change point in the slope of the curve. The change point represents the point in the x-axis where the slope significantly changes, equaling the rank where the abundance significantly

differs from the total trend. (Figure 1). Taxa ranked at or above the change point were kept as the dominant taxa. In cases where the change point fell on a rank which correlated with an abundance value shared by two or more taxa, all taxa sharing that abundance value were kept as the dominant taxa.

Figure 2: Curve Fitting (Change Point Analysis) for Dominant Taxa



Direct comparisons were made between samples collected at the same site or sites in close enough proximity to one another that differences in physical and chemical water quality parameters would be negligible (Zugbug Alley and Channel Cross Section 002; Wilson's and Downstream Wilson's). One similarity score was calculated between sample pairs of different sampling methodologies (i.e. vegetation rake, vegetation sweep, or Ponar grab) at the same site, and one similarity score was calculated between different habitat types (Chara, Z-grass, Eurasian milfoil, or Northern milfoil) at the same site. Total abundances of each taxon, dominant taxa abundances, and selected metrics were examined for differences using

the Bray-Curtis index. Bray-Curtis dissimilarity values were calculated using the Poptools addition for Microsoft Excel. Bray-Curtis distances are normalized to numbers between 0 and 1, with 0 being completely identical and 1 being completely dissimilar. For ease of comparison, we subtracted our values from 1 to create a measure of similarity. Bray-Curtis was chosen because it could compute a distance measure using the quantitative data of all the variables we wished to compare between samples.

Only samples collected at the same sites were directly compared because statistical analyses revealed a low average similarity of the total taxa abundances and dominant taxa present between samples from different sites, even among Ponar grab samples. There was also a difference between the similarity values (large range in similarity values) in terms of taxa abundances and dominant taxa present when comparing all Ponar grab samples. Ranges in similarity between sampling methodologies and average similarity between samples of different methodologies were calculated from Bray-Curtis scores. For the range in similarity, Bray-Curtis values were created for the complete dataset and the lowest and highest similarity values were used. For average similarity, all dissimilarity values for a sampling group were summed and the total was divided by the total number of values not equal to zero (when compared to itself a sample will have a dissimilarity of zero and similarity of 1). Dendrograms of dissimilarity between Ponar grabs and vegetation samples based on selected metrics were created using a Hierarchical Clustering analysis in NCSS (Hintze 2000).

Water Quality Parameters

The dominant substrates found at Fall River channel cross sections were sand and mud. Conductivity ranged from 152.2 $\mu S/cm^2$ to 209 $\mu S/cm^2$ while pH ranged from 7.57 to 8.78. Temperature ranged from 9°C to 10.7 °C and dissolved oxygen (D.O.) ranged from 9.5 to 12

mg/L. There was rain and a snow storm on the first day of sampling, November 7, 2005, which may have impacted the water chemistry. (Table 5.)

Table 5. Channel cross section water chemistry and substrate type.

Site Code	CCS001	CCS002	CCS003	CCS004	CCS005	CCS006	CCS007	CCS008
Date Collected	11/7/2005	11/8/2005	11/9/2005	11/9/2005	11/10/2005	11/10/2005	11/11/2005	11/11/2005
pH	8.78	7.7	8.17	8.27	7.57	7.63	7.85	7.84
EC (µS)	209	152.2	160.4	159.1	168.5	167.3	186.3	186
Temp (°C)	9.5	9.3	10.4	10.7	9.3	9.9	9	8.8
DO (mg/L)	11.4	12	9.8	11.6	9.5	10.9	9.9	9.5
Main substrate	mud	sand, mud	sand	mud	mud, sand	sand	sand	mud

RESULTS

Physical Cross Section Surveys

Four cross sections lost sediment and three sections gained sediment (cross sections are provided in Appendix VII) in the interval between the period when the DWR cross sections were completed and the fall of 2005. The change in sediment ranged from a 63.9 ft^2 loss to a gain if 45.4 ft^2. These amounts are quite low when compared to channel widths of 160 – 200 ft.

CCS002

The Spring Creek cross section (CCS002) is located on the Fall River approximately 60 yards downstream of the Spring Creek Bridge near the confluence of Spring Creek and the Fall River.

In our survey we used the cross section fence posts placed by DWR on each bank during their 1996-97 surveys. Our cross section profile matches up well with the DWR and SHN cross sections. We were unable to determine if the FRWTF also established a cross section at this site.

To compare CCS002 with DWR cross section #21 we added 6'0" of horizontal distance to each of our cross section stations to make our right bank endpoint (fence post) align with the DWR right bank endpoint (benchmark). We assume the differences were due to DWR placing their benchmarks (also their endpoints) six feet behind, and in-line with, their cross section fence posts. Unlike DWR, we used the cross section fence posts as our endpoints and placed our benchmarks behind them and in locations where they appeared to be least likely to be impacted by cattle or other disturbances.

We also subtracted 1.64' in elevation from the CCS002 t-post on the right bank to match the DWR endpoint and bring the two graphs into alignment (Appendix VII). The difference in elevation can likely be explained by advances in GPS technology and accuracy in the almost ten year span between surveys.

CCS003

Thomas Ryan Allotment (CCS003) is located approximately 3.5 miles upstream of the Spring Creek Bridge and 1.9 miles downstream of the confluence with Bear Creek. There was a clearly visible layer of sediment across the stream bottom at this site and the adjacent reaches of stream.

We located the survey monument for DWR cross section #9 on the left bank. We used this monument as our left bank benchmark and tied our survey into this point. We also located and used the DWR fence post on the left bank. We were unable to locate the DWR monument on the right bank. We did find a fence post on the right bank that was probably part of the DWR cross section. However, because there were small trees between the fence post and the stream bank we installed our right bank fence post approximately 10-15 feet downstream of the suspected DWR fencepost to gain an unobstructed line of sight from our instrument. The DWR right bank fence post is green with a white top; the UCD right bank fence post is red with a blue top. If the DWR cross section is to be replicated in future surveys it will be necessary to clear brush from around the right bank fence post to create a clear line of sight from the left bank.

Although the streambed is fairly uniform in the area of the cross section, CCS003 is not parallel to DWR cross section #9 and is slightly shorter in length (Appendix VII) so comparisons between the two may be of limited value.

When calculating changes in channel morphometry we had to apply the same 6' horizontal shift to the cross section measurements at CCS003 as we did at CCS002 (see above) to align

our cross section with the DWR cross section. We also subtracted 1.71 ft. from our left bank monument elevation to match the monument elevation of the DWR survey.

CCS004

The Fall River Ranch cross section (CCS004) is located in the upper Fall River approximately 1.9 miles above the confluence with Spring Creek and 1.6 miles downstream of CCS003. Our survey transect was set up on two existing fence posts that correspond with a graph of cross section 15b in the SHN report. SHN had also surveyed a cross section 15a in the same area however their report does not contain a graph or any data for cross section 15a.

SHN cross sections 15a and 15b were established at the proposed demonstration dredging project site (SHN 2002). The graph of cross section 15b in the SHN report is labeled with "DWR #15" in parentheses. However, this cross section does not resemble the profiles of the DWR Tetra Tech and FRWTF cross sections #15. To further confuse the issue, the SHN report does not contain a graph of cross section 15a and only addresses channel morphology in a single paragraph, with no detail. The lack of cross section information in the SHN report was apparently due to the cancellation of the demonstration dredging project. We believe that SHN mistakenly identified their cross 15b as the DWR cross section #15 and that SHN cross section 15a is the same site as DWR, Tetra Tech and FRWTF cross sections #15.

Endpoints on the graphs of the CCS004 and SHN 15b cross sections matched without any horizontal or vertical adjustments.

Total Abundances

CCS006 had the least number of invertebrates per square foot at 310 ft^{-2} followed by CCS004 at 556.44 ft^{-2}. CCS007 had the most invertebrates at 1594.67 ft^{-2} (Table 6).

Table 6. Abundance of macroinvertebrates collected using the Ponar grab sampling technique.

Site Name	CCS001	CCS002	CCS003	CCS004	CCS005	CCS006	CCS007	CCS008
Date Collected	11/7/2005	11/8/2005	11/9/2005	11/9/2005	11/10/2005	11/10/2005	11/11/2005	11/11/2005
Total per sample	4973	7160	6360	4173	9620	2325	11960	6780
Number per ft^2	829	1193	848	556	1283	310	1595	904

The number of invertebrates present per wet or dry weight of plant material was not calculated for the Z-grass sweep samples because the D-frame dip net does not collect vegetation. The Eurasian milfoil sample taken at CCS008 had the highest number of invertebrates per gram of plant material. The Z-grass rake taken from Vineyard had the least number of invertebrates per plant gram. Neither the Z-grass rake nor the Z-grass sweep sample taken from Vineyard reached the desired total of 300 invertebrates per sample. The Northern milfoil sample at Sportsman and the Z-grass rake sample at Wilson's also failed to reach 300 invertebrates per sample. The Z-grass sweep and Z-grass rake from Zugbug both had adequate numbers of invertebrates in the collected sample. Eurasian milfoil and Chara had the highest number of invertebrates per gram of plant material on average, although the Eurasian milfoil sample taken from Vineyard had a lower number of invertebrates per gram

than the Northern milfoil sample at Whipple Bend and the Z-grass sample at Zugbug Alley.

Complete lists of taxa abundances by individual taxa and by site can be found in Appendix IV.

Table 7. Total abundance of macroinvertebrates found in the invasive vegetation. All samples were collected using the rake technique described in the text.

Site Name	CHARINB001	Danford Bridge	Downstream Wilson's	CCS007	CCS008	Vineyard
Date Collected	11/10/2005	11/10/2005	11/11/2005	11/11/2005	11/11/2005	11/8/2005
Species	Chara	Chara	Chara	E milfoil	E milfoil	E milfoil
Total number identified	315	432	338	430	433	309
Total number collected	1400.00	2468.57	1690.00	4300.00	3464.00	588.57
Inverts per gram (wet weight)	15.51	24.28	19.40	54.09	66.01	4.72
Inverts per gram(dry weight)	324.74	403.74	325.00	505.88	759.65	204.64

Table 8. Total abundance of macroinvertebrates found in the native vegetation. All samples were collected using the rake technique described in the text with the exception of the Z-grass samples which were collected using the D-net sweep sample technique.

Site Name	Fall River Ranch	Sportsman	Whipple Bend	Vineyard	Wilson's	Zugbug	Vineyard	Zugbug
Date Collected	11/9/2005	11/9/2005	11/9/2005	11/8/2005	11/10/2005	11/8/2005	11/8/2005	11/8/2005
Species	No milfoil	No milfoil	No milfoil	Z-grass	Z-grass	Z-grass	Z-grass	Z-grass
Total number identified	364	266	391	131	219	371	160	324
Total number in sample	364.00	266.00	782.00	131.00	219.00	1349.09	160.00	648.00
Inverts per gram (wet weight)	2.92	2.89	8.29	1.31	1.99	9.60	NA	NA
Inverts per gram (dry weight)	178.43	203.05	267.81	103.97	195.54	276.87	NA	NA

Taxa of Interest

One taxa of particular interest is *Hexagenia* which was found in low abundance (3 individuals) only at CCS006. CCS006 did not have thick vegetation mats nor was much vegetation observed at this transect. Roots or submerged aquatic vegetation may interfere with oxygen exchange rates in the sediment. The fact that we found very few *Hexagenia* specimens is consistent with the 1996/1997 DWR study (which found none) but contradicts observations from the fishing community in Fall River which reported seeing the swarming adults. However, *Hexagenia* typically emerges in the summer and the early larval instars present in the fall would be quite small and easy to miss during sampling.

Some taxa were found only in one type of vegetation (Table 9). The absence of those taxa from the other types of vegetation samples may be a result of the small sample size, or the sample location (certain taxa may only be present in one section of the river). Because we

did not collect each type of vegetation at every site, we cannot determine from our data whether these invertebrates have preferences for a particular type of vegetation or if the invertebrates are dependent on certain plant species.

Z-grass samples had the lowest number of unique taxa. Z-grass is the least similar to the other plants in terms of plant structure, having thread-like, smooth edged leaves that are oppositely-arranged as opposed to the feather-like leaves of the milfoils which are arranged around the stem in whorls of 3-4 (DiTomaso and Healy 2003). One hypothesis that might explain the low number of taxa unique to Z-grass is that few taxa are able to utilize the plant architecture of Z-grass as well as Tricorythodes or Erpobdella, the two species unique to the Z-grass samples.

Table 9. Taxa unique to one vegetation type.

Taxa grouping	Final taxonomic identification	FFG	Z grass	Northern milfoil	Eurasian milfoil	Chara
Acari	Atractides sp.	P	0	present	0	0
Acari	Limnesia sp.	--	0	0	0	present
Annelida	Manayunkia speciosa	CF	0	0	present	0
Coelenterata	Hydra sp.	P	0	0	present	0
Coleoptera	Optioservus sp.	SC	0	present	0	0
Coleoptera	Haliplus sp.	MH	0	0	present	0
Coleoptera	Dubiraphia sp.	CG	0	0	present	0
Coleoptera	Agabus sp.	P	0	0	0	present
Ephemeroptera	Tricorythodes sp.	CG	present	0	0	0
Ephemeroptera	Paraleptophlebia sp.	CG	0	present	0	0
Ephemeroptera	Drunella spinifera	P	0	present	0	0
Ephemeroptera	Caenis sp.	CG	0	0	present	0
Gastropoda	Ferrissia sp.	SC	0	present	0	0
Gastropoda	Helisoma sp.	SC	0	present	0	0
Gastropoda	Juga sp.	SC	0	present	0	0
Hirudinea	Erpobdella sp.	P	present	0	0	0
Platyhelminthes	Platyhelminthes	--	0	0	present	0
Plecoptera	Leuctridae	SH	0	present	0	0
Trichoptera	Oxyethira sp.	PH	0	0	present	0
Trichoptera	Agraylea sp.	PH	0	0	present	0
Trichoptera	Leptoceridae	OM	0	0	present	0
Trichoptera	Mystacides sp.	OM	0	0	0	present
Trichoptera	Lepidostomatidae	--	0	0	0	present

0 = taxa not found in samples of this vegetation type.

CG= collector-gatherer, P= predator, SC= scraper, PH= piercer-herbivore, CF= collector-filterer, MH= macrophyte herbivore,

OM= omnivore, -- = No listed Functional Feeding Group

Dominant Taxa

The dominant taxa in the Fall River were mostly from the scraper-grazer and collector-gatherer functional feeding groups (FFG). Functional feeding groups were determined to be dominant if they represented 50 percent or more of all dominant taxa (Table 10). Other functional feeding groups included predators, parasites, shredders, collector-filterers, and piercer-herbivores. Fall River taxa were dominated by gastropods (Fluminicola, Vorticifex, and Valvata), Oligochaetes, Ephemeropterans (Ephemerella, Baetis, Pseudocloeon), Chironomids (Chironominae and Orthocladiinae), Trichopterans (Hydroptila, Amiocentrus), Amphipods (Hyalella), Bivalves (Sphaeriidae) and Ostracods. A full list of the dominant taxa by sample type and channel cross section can be found in Appendices I- III.

Both vegetation and sediment (Ponar) samples contained approximately the same number of dominant taxa. The number of taxa included in the dominant taxa list varied significantly among channel cross sections and vegetation type. CCS002 and CCS003 had 2 and 3 dominant taxa. CCS004 had the most dominant taxa (n = 14) (Table 10). Chara and Eurasian milfoil rake samples each had 3 dominant taxa while Z-grass samples had 8 or 9 dominant taxa depending on whether the sweep methodology (8 taxa) or rake methodology (9 taxa) was employed. Northern milfoil samples had 14 different taxa comprising the dominant taxa list (Table 10).

Metrics

Shannon diversity values normally range between 1.5 and 3.5. A low score indicates low taxa diversity (Magurran 1988). Evenness scores range from 0 to 1, and an evenness score of 1 indicates that all the taxa present are equally distributed. CCS003 had the lowest taxonomic richness (number of distinctly different taxa present) for Ponar grab samples with 16 taxa; this low richness was reflected in a Shannon diversity score of 1.51 – the lowest for all sites. CCS003 also had the lowest evenness score (0.54) for Ponar grab samples, indicating that the number of invertebrates were unevenly distributed among the few taxa in the sample. However, it should be noted that CCS003 supported the highest percentage of EPT (Ephemeroptera, Plecoptera, and Trichoptera) individuals, and that the percentage of EPT individuals (63%) at CCS003 was significantly higher than the percent of EPT individuals found in other sediment samples; percent EPT individuals ranged from 1 to 11% for all other Ponar grab samples. The percentage of EPT is expected to decrease in response to disturbance (Barbour et al. 1999). CCS003 also had a relatively low percentage (5%) of individual oligochaetes. CCS004 had the highest Shannon diversity and evenness score of all Ponar samples at 2.47 and 0.80, respectively. With 23 different taxa, CCS007 had the highest taxonomic richness score. CCS002 supported the highest numbers of oligochaetes at 36% of all individuals, while CCS001 contained the lowest percentage at 3%. The sediment from CCS001 contained the highest percentage (16%) of chironomid individuals (Table 10).

Northern milfoil and Eurasian milfoil samples had similar taxonomic richness and Shannon diversity scores (Table 11). Northern milfoil samples had the highest diversity on average, while Eurasian milfoil had the highest taxonomic richness on average. Evenness scores for these vegetation types ranged from 0.56 to 0.78. Chara samples had the lowest taxonomic richness, Shannon diversity score, and evenness score of all macrophyte samples. Eurasian milfoil had the highest percentage of chironomid individuals on average at 39% which was significantly higher than any other vegetation type. Other vegetation supported from 0 to 6 % Chironomidae individuals. Northern milfoil and Z-grass supported higher percentages of EPT individuals at 48 and 34% of individuals belonging to the Ephemeroptera, Trichoptera, or Plecoptera orders. Vineyard samples, regardless of whether or not they were Z-grass or Eurasian milfoil, supported higher percentages of EPT than Z-grass or Eurasian milfoil samples taken from other sites.

Table 10. The number of dominant taxa and the dominant functional feeding group for samples collected on the Fall River.

Sample type/Location	Dominant FFG	Number of dominant taxa
All Fall River	CG	14
Ponar	SC, CG	14
CCS001 Ponar	SC	4
CCS002 Ponar	CG	3
CCS003 Ponar	CG	2
CCS004 Ponar	CG	16
CCS005 Ponar	SC, CG	10
CCS006 Ponar	CG	10
CCS007 Ponar	CG	4
CCS008 Ponar	CG	6
Vegetation rake	CG	15
Chara rake	SC	3
E milfoil rake	CG	3
No milfoil rake	CG	14
Z-grass rake	CG	9
Z-grass sweep	CG	8
Z-grass combined	CG	7

FFG = functional feeding group: CG = collector-gatherer, SC= scraper.

Table 11. Selected Metrics per Individual Sample

Site	Sample Type	Taxonomic Richness	Shannon diversity	Evenness	Percent EPT	Percent Oligochaeta	Percent Chironomidae
CCS001	Ponar	17	1.72	0.61	0.01	0.03	0.16
CCS002	Ponar	22	2.09	0.68	0.11	0.36	0.03
CCS003	Ponar	16	1.51	0.54	0.63	0.05	0.08
CCS004	Ponar	22	2.47	0.80	0.10	0.12	0.09
CCS005	Ponar	21	2.26	0.74	0.03	0.34	0.06
CCS006	Ponar	20	2.09	0.70	0.10	0.15	0.08
CCS007	Ponar	23	2.21	0.70	0.02	0.33	0.03
CCS008	Ponar	20	1.95	0.65	0.05	0.23	0.04
CHARINB001*	Chara rake	12	1.55	0.62	0.31	0.00	0.00
Danford Bridge*	Chara rake	15	1.47	0.54	0.15	0.00	0.01
Downstream Wilson's	Chara rake	13	1.33	0.52	0.13	0.00	0.00
CCS007	E milfoil rake	23	2.19	0.70	0.06	0.02	0.57
CCS008	E milfoil rake	17	2.15	0.76	0.12	0.02	0.44
Vineyard	E milfoil rake	24	2.41	0.76	0.49	0.12	0.17
Fall River Ranch*	No milfoil rake	19	2.24	0.76	0.56	0.01	0.05
Sportsman*	No milfoil rake	15	2.15	0.80	0.45	0.00	0.07
Whipple Bend*	No milfoil rake	27	2.46	0.75	0.44	0.00	0.03
Vineyard	Z-grass rake	18	2.25	0.78	0.44	0.02	0.07
Wilson's	Z-grass rake	18	2.22	0.77	0.29	0.06	0.11
Zugbug	Z-grass rake	10	1.80	0.78	0.28	0.00	0.01
Vineyard	Z-grass sweeps	13	1.92	0.75	0.47	0.00	0.00
Zugbug	Z-grass sweeps	11	1.70	0.71	0.28	0.00	0.01

*Shannon diversity metrics for these samples were calculated using CalEDAS only.

Table 12. Selected Metrics per Vegetation Type*

Vegetation Type	Taxonomic Richness	Shannon AEAL	Evenness	Percent EPT	Percent Oligochaeta	Percent Chironomidae
Chara rake	13.33	1.45	0.56	0.20	0.00	0.00
E milfoil rake	21.33	2.25	0.74	0.23	0.05	0.39
No milfoil rake	20.33	2.28	0.77	0.48	0.01	0.05
Z grass rake	15.33	2.09	0.78	0.34	0.03	0.06

*Metrics were averaged per each vegetation type

Bray-Curtis Similarity

Taxa abundances

Bray-Curtis Similarity scores of taxa abundances demonstrate the similarity among samples that occur in the Fall River (Ponar grab samples and vegetation samples combined). A

similarity value of 68% can be considered a moderately strong similarity between methodologies or samples. (Herbst and Silldorff 2004).

The Z-grass methodologies turned out to have the highest degree of similarity in terms of Fall River taxa abundances at 55-66% similarity. Both Z-grass methodologies resulted in taxa abundances that were equally dissimilar to Ponar grab samples. When considering samples collected from the same location, vegetation samples also had a higher similarity to other vegetation samples than they did with Ponar grab samples. This trend was expected since sediment is expected to contain different taxa than submerged macrophytes. Different vegetation samples collected by the rake methodology (E milfoil and Z-grass as well as Chara and Z-grass) at the same sampling location did not have a high degree in similarity in taxa abundance (45 to 51% similarity) (Table 13).

Table 13. Similarity of taxa abundances between samples taken from the same location. Similarity is (1-Dissimilarity) as calculated by the Bray-Curtis method.

Site(s)	Comparison	Similarity
Vineyard	Z-grass sweep to Z-grass rake	0.55
Zugbug	Z-grass sweep to Z-grass rake	0.66
CCS 007	Ponar Grab to E milfoil rake	0.32
CCS 008	Ponar Grab to E milfoil rake	0.31
Vineyard	E milfoil rake to Z-grass rake	0.45
CCS 002/ Zugbug	Ponar Grab to Z-grass rake	0.36
CCS 002/ Zugbug	Ponar Grab to Z-grass sweep	0.40
Wilson's/ Downstream Wilson's	Chara rake to Z-grass rake	0.51

Table 14. Ranges and average similarity of taxa abundances between samples according to sample type.

Method	Lowest similarity	Highest similarity	Range in similarity	Average Similarity
Ponar to Ponar	0.11	0.71	0.61	0.38
Within vegetation	0.13	0.71	0.58	0.15
E milfoil to E Milfoil	0.26	0.71	0.44	0.43
No Milfoil to No Milfoil	0.57	0.75	0.18	0.64
Chara to Chara	0.55	0.74	0.19	0.62
Z-grass rake to Z-grass rake	0.41	0.65	0.23	0.54
Z-grass sweep to Z-grass sweep*	0.55	0.55	0.00	0.45

*There are only two Z-grass sweep samples to compare.

Across the entire Fall River, Ponar samples showed a low degree of similarity to one another in terms of overall taxa abundances. Vegetation samples across the Fall River showed an even lower degree of similarity in terms of total macroinvertebrate abundances at 15% average similarity. The trend of higher Ponar grab similarity was expected since sediment samples were collected in areas with similar types of substrate (mud and sand) and therefore should have less variability in microhabitats than vegetation samples. Northern milfoil and Chara samples had the smallest range in similarity values between vegetation sample pairs. Eurasian milfoil samples had the largest range in similarity between sample pairs from 26 to 71% similarity in taxa abundances (Table 14).

Dominant Taxa

The percent similarity of dominant taxa between sample pairs taken at the same locations is similar to the similarity of complete taxa abundances. One minor exception is that different Z-grass methodologies for examining dominant taxa abundances are more similar to one another than to the methodologies for examining overall taxa abundances. Different

vegetation samples collected at the same site are only ~50% similar in regards to dominant taxa abundances (Table 15).

Table 15. Similarity of dominant taxa abundance between samples taken from the same location.

Site(s)	Comparison	Similarity
Vineyard	Z-grass sweep to Z-grass rake	0.63
Zugbug	Z-grass sweep to Z-grass rake	0.67
CCS007	Ponar Grab to E milfoil rake	0.28
CCS008	Ponar Grab to E milfoil rake	0.33
Vineyard	E milfoil rake to Z-grass rake	0.50
CCS002/ Zugbug	Ponar Grab to Z-grass rake	0.40
CCS002/ Zugbug	Ponar Grab to Z-grass sweep	0.43
Wilson's/ Downstream Wilson's	Chara rake to Z-grass rake	0.51

The resulting ranges in similarity and average similarity in terms of dominant taxa abundances between sample types were also similar to the Bray-Curtis results for taxa abundances. Chara and Northern milfoil had the highest similarity to one another across different sampling locations (Table 16).

Table 16. Ranges and average similarity of dominant taxa abundances between samples according to sample type.

Method	Lowest similarity	Highest similarity	Range in similarity	Average similarity
Ponar to Ponar	0.07	0.81	0.75	0.41
Within vegetation	0.14	0.81	0.67	0.42
E milfoil to E Milfoil	0.30	0.77	0.47	0.47
No Milfoil to No Milfoil	0.59	0.79	0.20	0.67
Chara to Chara	0.58	0.81	0.23	0.67
Z-grass rake to Z-grass rake	0.30	0.69	0.39	0.56
Z-grass sweep to Z-grass sweep	0.58	0.58	0.00	0.58

*There are only two Z-grass sweep samples to compare.

Selected Metrics

Metrics selected for comparison included taxa richness, Shannon diversity, evenness, percent EPT individuals, percent oligochaete individuals, and percent Chironomidae individuals. Sample pairs, regardless of sampling methodology or habitat type, were more similar to one another in terms of selected metrics than dominant taxa or complete taxa abundances. The least similar sample pairs taken from the same location were samples collected by Ponar grabs and Z-grass samples. All other sample pairs were highly similar to one another. For example, Eurasian milfoil and Ponar grab samples had 98% similarity between metrics (Table 17).

Ponar samples were more similar to one another than vegetation samples, which had a wide range in similarity between vegetation sample pairs. Metrics between all vegetation samples were on average 83% similar. Chara samples had the highest similarity of all vegetation types at 93% similarity in selected metrics (Table 18).

Table 17. Similarity of selected metrics between samples taken from the same location.

Site(s)	Comparison	Similarity
Vineyard	Z-grass sweep to Z-grass rake	0.85
Zugbug	Z-grass sweep to Z-grass rake	0.96
CCS007	Ponar Grab to E milfoil rake	0.98
CCS008	Ponar Grab to E milfoil rake	0.91
Vineyard	E milfoil rake to Z-grass rake	0.87
CCS002/ Zugbug	Ponar Grab to Z-grass rake	0.66
CCS002/ Zugbug	Ponar Grab to Z-grass sweep	0.69
Wilson's/ Downstream Wilson's	Chara rake to Z-grass rake	0.82

Table 18. Ranges and average similarity of selected metrics between samples according to sample type.

Method	Lowest similarity	Highest similarity	Range in similarity	Average similarity
Ponar to Ponar	0.80	0.99	0.19	0.92
Within vegetation	0.59	0.99	0.40	0.83
E milfoil to E Milfoil	0.83	0.96	0.12	0.89
No Milfoil to No Milfoil	0.75	0.90	0.15	0.83
Chara to Chara	0.90	0.95	0.05	0.93
Z-grass rake to Z-grass rake	0.75	0.99	0.24	0.83
Z-grass sweep to Z-grass sweep	0.92	0.92	0.00*	0.92

*There are only two Z-grass sweep samples to compare.

Direct comparison between vegetation types was also conducted using Bray-Curtis similarity. Northern milfoil samples have a lower similarity (83%) to other Northern milfoil samples than they do with Eurasian milfoil samples (88%) (Table 19). Most vegetation samples have the same similarity with the same vegetation as with other vegetation. The same similarity values further indicate that site.location may be the most influential factor in structuring the invertebrate community. With few samples and different locations, power analysis should be used to determine which variables, if any can differentiate between vegetation types. Power analysis would also calculate the number of samples necessary to detect differences according to each metric based on of the data from this study.

Table 19: Direct comparison between vegetation samples based on selected metrics*

Vegetation types being compared		Lowest similarity	Highest similarity	Range in similarity	Average similarity
Z grass	E milfoil	0.63	0.96	0.33	0.83
Z grass	No milfoil	0.59	0.97	0.38	0.84
Z grass	Chara	0.80	0.91	0.11	0.85
No milfoil	E milfoil	0.78	0.94	0.16	0.88
No milfoil	Chara	0.64	0.96	0.32	0.80
E milfoil	Chara	0.68	0.91	0.23	0.77

*Use with caution as vegetation samples were taken from different locations. Location influences taxonomic composition.

DISCUSSION

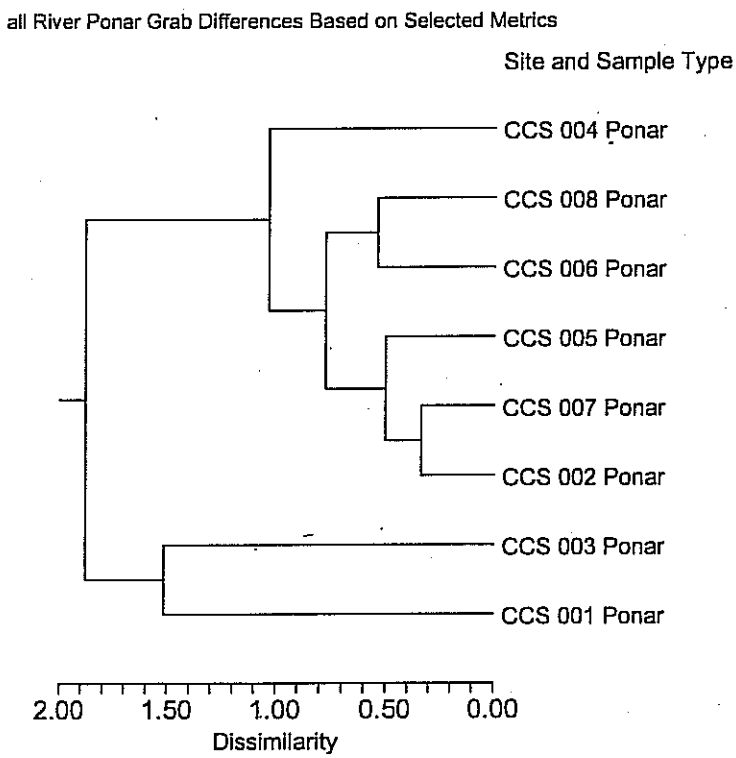
Ponar grab sediment samples

When examining total abundances (number of invertebrates per square feet or number of invertebrates per plant gram), it is necessary to remember that this metric has limitations in its ability to describe the aquatic community. A high number of invertebrates does not necessarily indicate a high biomass of invertebrates. For instance, the invertebrate population of a site could consist mostly of high numbers of chironomids which would equal a smaller biomass than a site with the same numbers of gastropods. A high biomass of invertebrates does not indicate a high biomass of invertebrates that are biologically available to predatory organisms such as fish. Despite these potential drawbacks, total abundances were calculated and compared to previous studies where the metric was utilized. The comparison is useful among sites that are otherwise similar in their diversity, evenness scores, or dominant taxa.

For instance, CCS006 had the lowest number of invertebrates per square feet, but it had a relatively high number of taxa representing the dominant taxa of the site. In other words, CCS006 did not have high abundances of just two or three distinct taxa; the taxa abundances

were distributed more evenly among different taxa. CCS004, which also had a relatively low number of invertebrates per square feet relative to the other channel cross sections, had the highest number of dominant taxa at 16 taxa. CCS004 also had the highest evenness score of 0.80 and the highest Shannon diversity score. The total abundances of CCS004 and CCS006 were composed of about 14% oligochaete individuals on average. The sites that had the highest number of invertebrates per square feet, CCS007, CCS005, and CCS002, were comprised of about 34% oligochaete individuals on average. CCS002 and CCS007 had lower numbers of dominant taxa at 3 and 4 taxa each. CCS005 had 10 dominant taxa and a high evenness score of 0.74, so even though it had high numbers of oligochaetes CCS005 also had higher numbers of individuals in each other taxon present. In summary, even though CCS002 and CCS007 had high numbers of invertebrates per square feet, they were not as diverse nor did they have as high numbers of dominant taxa as sites with lower number of invertebrates. The higher number of individuals at CCS002 and CCS007 were mostly due to high abundances of oligochaetes.

Figure 3. Dendrogram of dissimilarity between Ponar grabs based on selected metrics. See text for details on the metrics used in the analysis.



CCS003 ranked the lowest in terms of diversity, evenness, and number of dominant taxa. However, CCS003 also contained a significantly higher percentage of EPT individuals than other sites and had a low percentage of oligochaete individuals.

The low Bray-Curtis similarity scores on average and the wide range in similarity values between Ponar grab samples in terms of taxa abundances or dominant taxa abundances indicate that taxa abundances, even among the dominant taxa which are highly represented along a majority of Fall River, vary depending upon the location along Fall River. The Ponar grab methodology was consistent between samples and the sediment type also appeared relatively consistent between sites. Therefore, differences in taxonomic composition and abundances are most likely due to other variables such as physical habitat parameters (water

depth and velocity, surrounding aquatic and riparian vegetation) or water chemistry parameters other than the ones measured for this study.

The two sites that were the most similar in terms of complete taxa abundances were CCS007 and CCS008 at 71% similar. The two sites that were the most similar in terms of dominant taxa abundances were CCS002 and CCS007 at 81% similar.

Vegetation samples

Eurasian milfoil samples and Chara samples on average had the higher number of invertebrates per gram of plant material than the native vegetation. Z-grass samples contained the lowest number of invertebrates per plant gram on average. These differences in total abundances, as stated above, may be more influenced by the section of the river in which these samples were collected than the type of vegetation from which they were collected. When examining the individual vegetation samples, for instance, it should be noted that two of the Eurasian milfoil samples were collected from CCS008 and CCS007 which had an average to above average number of invertebrates in Ponar grab samples compared to other sites. Two Z-grass rake samples failed to meet the minimum number of 300 invertebrates per sample, but one Z-grass rake sample had higher numbers of invertebrates per plant gram than a Eurasian milfoil sample. The Z-grass sample with high abundances was collected at Zugbug which is in close proximity to CCS002, a site that also had above average Ponar grab total abundance numbers. The Eurasian milfoil sample with the lower number of invertebrates than the Z-grass sample was collected at Vineyard, which was a site that also contained the lowest number of invertebrates of any Z-grass sample. To

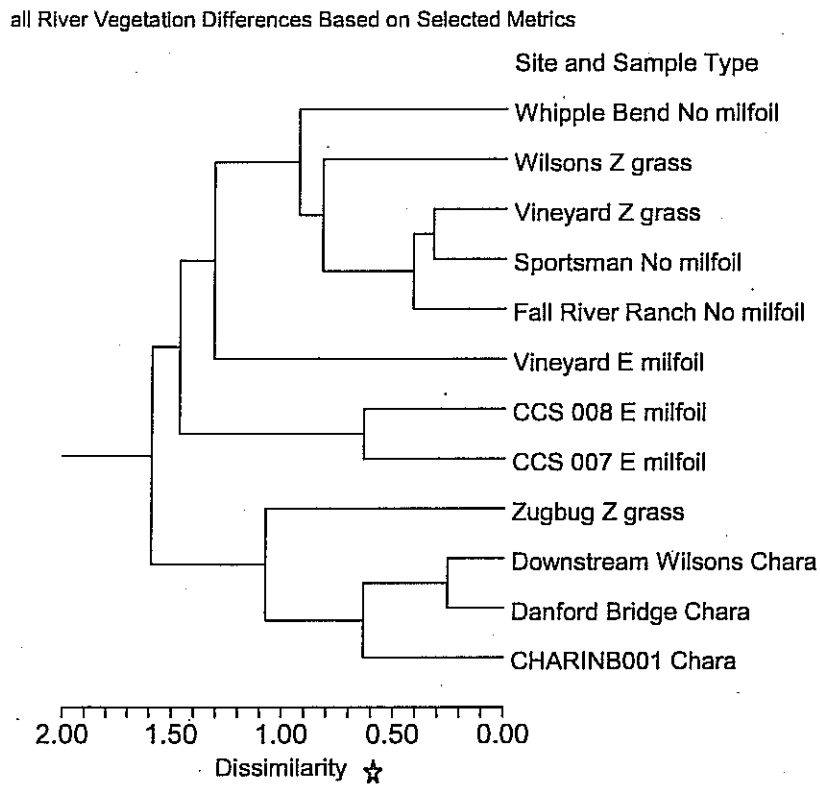
separate the differences between low numbers of invertebrates per plant gram due to vegetation type and low numbers of invertebrates due to site location, it will be necessary to collect more plant samples from the same site location along the river. Then more accurate hypotheses regarding total invertebrate abundances to plant type and structure can be formed.

The location of the macroinvertebrate sample within the macrophyte bed can also influence the abundances of macroinvertebrates found. Samples collected at the upper and outer edges of macrophyte beds are generally higher in macroinvertebrate abundances than samples collected in the lower and interior edges (Sloey et al. 1987 as cited in Cheruvelil et al. 2001). Samples were most often taken from the upper edge of macrophyte beds due to the difficulty of sampling from the boat, but the depth within the macrophyte bed varied as the depth of the vegetation from the surface of the water varied between sampling sites. Detailed notes about the location of the samples were not recorded as it was often dark at the time of sampling and difficult to locate the different vegetation types. Macrophyte beds that were as homogeneous as possible were selected due to the difficulty of targeting and grabbing only one type of vegetation with the rake method. Homogeneous macrophyte beds support lower abundances of invertebrates than heterogeneous macrophyte beds (Brown et al. 1988 as cited in Cheruvelil et al. 2001), and thus the abundances from this preliminary study may not accurately represent the true abundance found in each type of macrophyte across the entire patch.

Northern milfoil samples and Z-grass samples had more dominant taxa than nonnative plants at 14 and 9 taxa, respectively. Eurasian milfoil samples had a lower number of dominant taxa at 3 taxa, but Eurasian milfoil samples had the highest taxonomic richness (total number

of taxa), high Shannon diversity score, and a high evenness score of 0.74. The high diversity comes from low but equally distributed abundances of non-insect taxa, Trichoptera taxa, and Coleoptera taxa. Eurasian milfoil samples had significantly higher percentages of Oligochaete individuals than other macrophyte samples. Eurasian milfoil samples, Northern milfoil samples, and Z-grass samples had similar evenness scores. Since Z-grass and Northern milfoil samples had more dominant taxa than Eurasian milfoil, the evenness scores for the native plants indicated that native plants had an even distribution of abundances that composed a large enough proportion of the sample to be considered dominant. Eurasian milfoil samples, on the other hand, had an even distribution of multiple taxa in low abundances and a few taxa that composed a majority of total individuals. Northern milfoil samples had the highest percentage of EPT individuals. Z-grass samples also had a higher percentage of EPT than Eurasian milfoil. Chara samples had the lowest Shannon diversity and evenness scores and the same number of dominant taxa (3) as Eurasian milfoil samples.

Figure 4. Dendrogram of dissimilarity in macroinvertebrate communities between vegetation samples based on metrics. Metrics are described in the text.



* Dissimilarity values in the dendrogram are different from Bray Curtis dissimilarity values.

In terms of total taxa abundances, Northern milfoil samples and Chara samples varied the least across Fall River sampling locations. In other words, taxa abundances were similar in Northern milfoil and Chara samples regardless of sampling location. The abundances of the dominant taxa were also more similar in Northern milfoil and Chara samples than other macrophyte samples. Abundances of all taxa and dominant taxa in Eurasian milfoil exhibited the greatest variability and consequently the least similarity across sampling locations. This variation may be due to the sample taken at Vineyard which had large percentages of EPT taxa while other Eurasian milfoil samples with similar taxonomic richness contained larger numbers of Chironomids and Gastropods. Therefore, site-specific factors may influence total

macroinvertebrate abundances or the abundance of dominant taxa as much as vegetation type. If location along the river significantly influences the abundances of individual macroinvertebrate taxa, it provides an explanation for why Eurasian milfoil has the least similarity between macroinvertebrate abundance and dominant taxa abundances. Eurasian milfoil collection sites spanned the greatest distance along the Fall River. The Bray-Curtis similarity scores further indicate the necessity of collecting samples in the same location to have a better comparison of taxa abundances and dominant taxa abundances between different species of aquatic plant.

As with Ponar grabs, selected metrics such as taxonomic richness, Shannon diversity, evenness, and percentage oligochaetes, percentage EPT, and percentage Chironomidae were more similar than taxa abundances or dominant taxa abundances between vegetation samples. Chara samples were the most similar in terms of these metrics.

Comparison of Results to Previous Studies

There were two previous studies conducted along the Fall River that studied macroinvertebrates along channel cross sections. The first was conducted by DWR in 1996 and 1997 and the second was conducted by SHN Engineers and Consulting in 1998 and 2000. While the AEAL possesses partial final reports for both these projects, the methods and results sections in these reports were unclear in many places, thus making comparisons difficult.

Three sites were the same between the two previous studies and the one conducted by the AEAL in 2005. Those sites were CCS004, CCS003, and CCS002 (Table 20).

Table 20. Site codes and descriptions of channel cross sections from the two previous studies of macroinvertebrates in the Fall River compared to the current study.

AEAL Site Code	CCS004	CCS002	CCS003
AEAL Site Description	Gasline (Fall River Ranch)	Downstream of Spring Creek Bridge	Thomas Ryan Allotment
DWR Site Code	NA	Cross Section 21	NA
DWR Site Description	NA	Downstream from Spring Creek Bridge	NA
SHN Site Code	Transect 15b	Transect 21	Transect 9

The following modifications were made to facilitate comparability of data. The SHN study reported the number of macroinvertebrates per square meter; those numbers were converted to number of invertebrates per square foot. Percentages of Oligochaetes, Chironomidae, and EPT individuals were calculated from total taxon counts in the appendices of both the SHN report and the DWR report.

The taxonomic richness and Shannon diversity appear to have decreased at CCS002 compared to the DWR study performed in 1996, but there appears to be an increase in both diversity and taxonomic richness from SHN 2000 to 2005. AEAL Shannon diversity and taxonomic richness of CCS 002 are more similar between DWR Spring 1997 and AEAL Fall 2005. The differences in diversity index and number of species may be attributed to different levels of taxonomic resolution. SHN used orders to calculate diversity, while the AEAL used the lowest taxonomic resolution possible (with the exception of chironomids and

oligochaetes). Also, it is rare that Shannon diversity numbers are above 3.5. Such high Shannon diversity indices usually indicate an extremely pristine site. (Table 21).

Table 21. Comparison of AEAL results to previous Fall River studies

CCS 004, Cross Section 15(b)				
Agency/ Date Sampled	DWR Fall 1996	DWR Spring 1997	SHN Summer 2000	AEAL Fall 2005
Macroinvertebrates per ft^2	NA	NA	3,110.22	556.44
Percent Oligochaetes	NA	NA	0.31	0.12
Percent EPT	NA	NA	0.04	0.10
Percent Chironomidae	NA	NA	0.42	0.09
Taxa Richness (# of species)	NA	NA	NA	22.00
Number of Orders	NA	NA	13.00	14.00
Shannon Diversity Index*	NA	NA	0.71	2.47
CCS 002, Cross Section 21				
Agency/ Date Sampled	DWR Fall 1996	DWR Spring 1997	SHN Summer 2000	AEAL Fall 2005
Macroinvertebrates per ft^2	2400.00	1148.00	7514.50	1193.33
Percent Oligochaetes	0.27	0.52	0.52	0.36
Percent EPT	0.21	0.07	0.09	0.11
Percent Chironomidae	0.05	0.30	0.03	0.03
Taxa Richness (# of species)	37.00	24.00	NA	22.00
Number of Orders	16.00	9.00	11.00	16.00
Shannon Diversity Index*	4.10	2.90	0.65	2.09
CCS 003, Cross Section 9				
Agency/ Date Sampled	DWR Fall 1996	DWR Spring 1997	SHN Summer 2000	AEAL Fall 2005
Macroinvertebrates per ft^2	NA	NA	2155.90	848.00
Percent Oligochaetes	NA	NA	0.69	0.05
Percent EPT	NA	NA	0.02	0.63
Percent Chironomidae	NA	NA	0.33	0.08
Number of Orders	NA	NA	11.00	10.00
Shannon Diversity Index*	NA	NA	0.44	1.51

*Shannon-Weaver Index of Diversity was used for DWR and AEAL studies. The SHN calculated Shannon Weaver diversity using orders, therefore values are not directly comparable.

Another noticeable difference between the AEAL Fall 2005 study and previous studies is the change in total abundances. AEAL found higher numbers of macroinvertebrates per square feet than DWR found in 1996 and 1997. However, AEAL had significantly lower total abundances than SHN. The differences between AEAL and the DWR study may be minimized since similar methodology and the same sized Ponar grab sampler were employed. It is unclear what size Ponar grab was employed by SHN. Methodological differences such as a difference in the size of the Ponar grab used may result in a significant difference in density estimates. A study performed by Herbst and Silldorff demonstrated a difference in density estimates of up to 50% between two sampling net methods (Herbst and Silldorff 2004). The performance of Ponar grab samplers can also be influenced by items such as plant material catching in the Ponar grab claw and dislodging material. Another factor that could influence the density estimates is the inclusion of macrophytes as sample material. The AEAL sought to eliminate the use of grabs that contained more than 50% macrophyte material (stems, leaves, and root material) in order to accurately estimate the abundance of macroinvertebrates per square foot of sediment material. SHN sampled sand and vegetation for the CCS 002 sample (SHN Consulting Engineers and Geologists, Inc; 2002).

The percent of individuals in specific taxa was also different between the SHN study and the AEAL 2005 study. Percent EPT increased from 2000 to 2005 while percent oligochaetes decreased over time. Percent of Chironomidae individuals was the same for CCS002, but decreased at CCS004 and CCS003.

CONCLUSIONS

CCS003 was the least diverse of all channel cross sections in terms of macroinvertebrate taxa, but contained the highest percentages of EPT individuals. CCS004 had low densities of invertebrates, but had high numbers of dominant taxa, low percentages of oligochaetes, and was the most diverse of all channel cross sections. CCS002 and CCS007 had high densities of invertebrates, but low diversity, low numbers of dominant taxa, and high abundances of oligochaetes. CCS005 contained high densities of invertebrates and high and equal abundances of oligochaetes and many other taxa. *Hexagenia* was found at very low abundances at CCS006. The abundance of taxa varied significantly depending on the location along the Fall River, but CCS007 and CCS008 were moderately similar to one another in terms of total taxa abundances and CCS007 and CCS002 were moderately similar to one another in terms of dominant taxa abundances. Sediment and basic water chemistry were similar between channel cross sections, so other variables such as flow, sedimentation, water chemistry influenced by surrounding land use (nutrients for example), and different species of aquatic vegetation must influence the abundances of the taxa. While we were able to document differences in the macroinvertebrate communities associated with different species of aquatic vegetation (see below), we were unable to definitively associate specific parameters with differences in the macroinvertebrate communities.

Chara supported the least diverse macroinvertebrate community of all plant species. Z-grass and Northern milfoil samples contained higher percentages of EPT individuals than Eurasian milfoil samples. Z-grass and Northern milfoil samples also had a greater number of taxa that occur at high abundances (greater number of dominant taxa). Eurasian milfoil and Northern milfoil samples had the highest taxonomic richness. Eurasian milfoil had the highest

abundances of Chironomids. Vineyard samples appeared to be rich in EPT regardless of the species of vegetation sampled. Taxa abundances in the same species of vegetation varied across different locations along the Fall River. Taxa abundances varied the least across different site locations in Northern milfoil or Chara samples. More research should be performed to compare total abundances (densities) and biomass of macroinvertebrates associated with different species of vegetation to determine which properties of the individual species are critical to different species of macroinvertebrates.

Location along Fall River was highly influential on the macroinvertebrate community collected by Ponar grab samples and vegetation samples. It was therefore difficult to compare the macroinvertebrate communities in different species of vegetation when there were only a few samples from the same site. Differences in macroinvertebrate community composition across vegetation types could be detected using different metrics, but the number of samples needed to detect the differences varies (see below 'Power analysis to determine number of vegetation samples needed' for more details). Which metrics or which taxa are the most important for the existing fish community should be determined in order to optimize future research involving macroinvertebrates and macrophytes (see 'Suggestions for future research' for more details).

SUGGESTIONS FOR FUTURE RESEARCH

Future studies should be expanded in scope to allow multiple vegetation samples (more than the three per plant species) from the same location. This will allow the identification of differences in macroinvertebrate communities across plant species with greater statistical

power than we were able to do in this preliminary study. The current study and previous research has demonstrated that macroinvertebrate communities can exhibit large species to species variability. The variations in macroinvertebrate communities between plant species can be attributed to many factors and include predation, patterns of macroinvertebrate emergence, oxygen concentration, water circulation, and fluctuating food supply (Cheruvelil et al. 2000, Strayer et al. 2003). In the future, duplicate samples should be collected from the same site location to allow for a comparison of samples taken from the same plant species. It would then be possible to determine how repeatable the weed rake and other sampling methods are in terms of total taxa abundances, selected metrics, and dominant taxa within the same plant type. Ideally, samples using the same methodology should also be collected at the same location from different plant species.

The differences in macroinvertebrate abundances between differing vegetation density and location of the sample within a macrophyte bed could also be determined from examining more than one sample of the same plant species per site. Invertebrate communities could vary depending on the vertical location of a sample in the macrophyte canopy. Past research has demonstrated that there can be a change in the invertebrate community depending on where in a macrophyte habitat patch the sample is collected (Bailey and Litterick 1993, and Masifa et al. 2001 as cited in Toft et al. 2003). Macroinvertebrate density is generally higher in the interior of vegetation beds. (Strayer et al. 2003). A large number of samples collected randomly across the macrophytes bed will remove these differences from consideration in the analyses.

More information about the habitat requirements of epiphytic macroinvertebrates needs to be gathered. Aquatic plants can reduce the penetration of light and thus reduce the amount of photosynthetic activity. The reduction of photosynthetic activity results in reduced dissolved oxygen which can negatively impact various invertebrates (Ogbogu 2001). Plant architecture can also influence macrophyte invertebrate abundances. For example, invertebrate abundances have been found to be higher in plants with dissected leaves; possibly because dissected leaves provide more habitats, more epiphyton for scrapers (grazers), and more protection from predators (Cheruvelil et al. 2000).

Future research examining the foraging capability of fish in and around different macrophytes as well as the contribution of macroinvertebrates present in aquatic vegetation to fish diets should be conducted. Many species of juvenile fish feed on epiphytic macroinvertebrates that use submerged macrophyte beds and for cover from predation (Cheruvelil et al 2000). Abundances of invertebrates between different plant communities may be the same, but the ability of fish to forage for those invertebrates can vary significantly between plant communities (Dibble and Harrel 1997). Enclosures could be set up to examine the changes and differences in invertebrate communities with and without fish over time. These enclosures could be maintained with different plant types and or densities. Fish diets could be monitored and compared between plant types (Kornijow et al. 2005, Dibble and Harrel 1997, Toft et al. 2003).

POWER ANALYSIS TO DETERMINE NUMBER OF VEGETATION SAMPLES NEEDED

Power analysis was used to determine the number of vegetation samples needed to detect a statistically significant difference between vegetation types in NCSS Number Cruncher Statistical System (Hintze 2000). The metrics in this study as well as the abundance of invertebrates per dry weight vegetation material were also examined. The power to detect differences between vegetation samples using individual metrics and abundance of invertebrates per dry weight of plant material were also calculated using the numbers of replicates taken per each vegetation type in this study.

Greater statistical power ($1 - \beta$) is achieved by minimizing β (the probability of failing to reject a false null hypothesis) (Peterman 1990a as cited in Cheruvelil et al. 2000). The greater the power, the greater is the confidence that the stated hypothesis is true. In other words, power is the probability of rejecting a false null hypothesis (Hintze 2000). 'Conservative' estimates of the number of samples necessary to detect differences set α and β to 0.05, while more 'liberal' estimates set α at 0.05 and β at 0.20 (Peterman 1990b as cited in Cheruvelil et al. 2000). When β equals 0.20, power equals ~0.80. Power values range from 0 to 1, with greater values indicating greater statistical power. Power should be close to 1 (Hintze 2000).

The 'liberal' estimates were used to report minimum numbers of samples needed to detect differences between vegetation types and to detect the power of the differences between vegetation samples used in this study. The mean values of the three replicates for each vegetation sample from this study were entered into NCSS. Means and standard deviations

were determined for each metric and vegetation type. The means are expected to vary between vegetation types, but standard deviation is assumed to be common for all vegetation types. Each vegetation type had a different standard deviation between the replicates. Therefore, the largest standard deviation was chosen for addition into NCSS. In general, a larger standard deviation results in a greater number of samples that will be required to detect a different between vegetation types. A larger standard deviation was found to decrease the statistical power of the results found per metric in this study. In other words, the greater the standard deviation between replicates is the greater chance of failing to reject a null hypothesis. The following results indicating the number of samples needed should be considered to be the bare minimum number of samples needed, as our power analysis was based off of three replicates per each plant type and there is a high variability associated with epiphytic macroinvertebrates (Cheruvelil et al. 2000).

The power to detect differences between in macroinvertebrate community metrics in different species of vegetation in this study, and the numbers of samples that need to be taken in order to detect differences varies depending on the invertebrate metric being examined. Shannon diversity and evenness values differentiate between vegetation types with a statistical power >0.80. Evenness achieves 93% power to differentiate between the means of different vegetation types when taking a total of 12 samples or three samples per vegetation type (Table 22). Shannon diversity differentiates between vegetation types with 80% power when collecting three samples per vegetation type (Table 22). Three samples per vegetation type were not enough to differentiate between vegetation types when examining other metrics with significant statistical certainty. It was therefore necessary to calculate the

number of samples it would take to differentiate between vegetation types with a power of 0.80 (Table 23).

Table 22. Power to detect differences in macroinvertebrate metrics developed from collections in different species of vegetation in this study.

Metric/ Variable	Power	Standard deviation used
Inverts per plant biomass (dry weight)	0.20	226.86
Taxonomic Richness	0.22	6.00
Shannon AEAL	0.87	0.25
Evenness	0.93	0.06
Percent EPT	0.17	0.23
Percent Oligochaeta	0.11	0.06
Percent Chironomidae	0.40	0.20

If an objective of the study was to differentiate between plant types on the basis of the percentage of Oligochaetes with 80% power, an individual would need to collect 26 samples per vegetation type. If the objective were to differentiate between vegetation types using taxonomic richness or abundance per biomass with 80% power, the individual would need to collect 11 samples per vegetation type (Table 23).

Table 23. Number of samples needed to detect differences between vegetation types.

Metric/ Variable	Power	Number of samples needed
Inverts per plant biomass (dry weight)	0.80367	11
Taxonomic Richness	0.83862	11
Shannon AEAL	0.87142	3
Evenness	0.93196	3
Percent EPT	0.80122	13
Percent Oligochaeta	0.81113	26
Percent Chironomidae	0.83928	6

In summary, the number of vegetation samples an individual would need to collect varies according to the desired metric. The best variables to use when interpreting differences between vegetation types in this study would be Shannon diversity or evenness.

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APPENDICES

APPENDIX I: DOMINANT TAXA BY SAMPLE TYPE

Sample type	Taxon	Tol Val	FFG	Distinct	TOTAL	RANK	PERCENT
all Fall River	Fluminicola sp.	5	SC	D	1562	1	0.2528326
all Fall River	Oligochaeta	5	CG	D	556	2	0.0899968
all Fall River	Vorticifex sp.	--	SC	D	446	3	0.0721916
all Fall River	Ephemerella sp.	1	CG	D	362	4	0.058595
all Fall River	Hyalella sp.	8	CG	D	337	5	0.0545484
all Fall River	Chironominae	6	CG	D	306	6	0.0495306
all Fall River	Baetis sp.	5	CG	D	274	7	0.0443509
all Fall River	Ostracoda	8	CG	D	243	8	0.0393331
all Fall River	Hydroptila sp.	6	PH	D	234	9	0.0378763
all Fall River	Valvata sp.	8	SC	D	226	10	0.0365814
all Fall River	Sphaeriidae	8	CG	D	214	11	0.034639
all Fall River	Amiocentrus aspilus	3	CG	D	207	12	0.033506
all Fall River	Orthocladiinae	5	CG	D	201	13	0.0325348
all Fall River	Pseudocloeon sp.	--	CG	D	123	14	0.0199094
Ponar	Oligochaeta	5	CG	D	487	1	0.2026633
Ponar	Fluminicola sp.	5	SC	D	390	2	0.1622971
Ponar	Valvata sp.	8	SC	D	223	3	0.0928007
Ponar	Ephemerella sp.	1	CG	D	221	4	0.0919684
Ponar	Sphaeriidae	8	CG	D	206	5	0.0857262
Ponar	Hyalella sp.	8	CG	D	171	6	0.071161
Ponar	Chironominae	6	CG	D	87	7	0.0362047
Ponar	Vorticifex sp.	--	SC	D	82	8	0.034124
Ponar	Helisoma sp.	6	SC	D	62	9	0.0258011
Ponar	Ostracoda	8	CG	D	60	10	0.0249688
Ponar	Gyraulus sp.	8	SC	D	58	11	0.0241365
Ponar	Tanypodinae	7	P	D	56	12	0.0233042
Ponar	Helobdella sp.	6	PA	D	37	13	0.0153974
Ponar	Hydroptila sp.	6	PH	D	27	14	0.011236

APPENDIX I: DOMINANT TAXA BY SAMPLE TYPE

Sample type	Taxon	Tol Val	FFG	Distinct	TOTAL	RANK	PERCENT
vegetation rake	Fluminicola sp.	5	SC	D	988	1	0.2981291
vegetation rake	Vorticifex sp.	--	SC	D	322	2	0.0971635
vegetation rake	Chironominae	6	CG	D	218	3	0.0657815
vegetation rake	Amiocentrus aspilus	3	CG	D	205	4	0.0618588
vegetation rake	Hydroptila sp.	6	PH	D	194	5	0.0585395
vegetation rake	Baetis sp.	5	CG	D	186	6	0.0561255
vegetation rake	Orthocladiinae	5	CG	D	186	7	0.0561255
vegetation rake	Hyalella sp.	8	CG	D	162	8	0.0488835
vegetation rake	Ostracoda	8	CG	D	136	9	0.041038
vegetation rake	Ephemerella sp.	1	CG	D	106	10	0.0319855
vegetation rake	Pseudocloeon sp.	--	CG	D	104	11	0.031382
vegetation rake	Oligochaeta	5	CG	D	69	12	0.0208208
vegetation rake	Isoperla sp.	2	P	D	50	13	0.0150875
vegetation rake	Hydroptilidae	4	PH	N/D	44	14	0.013277
vegetation rake	Tanypodinae	7	P	D	33	15	0.0099578

APPENDIX II: DOMINANT TAXA BY VEGETATION TYPE

Sample type	Taxon	Tol Val	FFG	Distinct	TOTAL	RANK	PERCENT
Chara rake	Fluminicola sp.	5	SC	D	521	1	0.5788889
Chara rake	Hydroptila sp.	6	PH	D	97	2	0.1077778
Chara rake	Vorticifex sp.	--	SC	D	55	3	0.0611111
E milfoil rake	Baetis sp.	5	CG	D	195	1	0.2169077
E milfoil rake	Pseudocloeon sp.	--	CG	D	140	2	0.1557286
E milfoil rake	Fluminicola sp.	5	SC	D	100	3	0.1112347
No milfoil rake	Fluminicola sp.	5	SC	D	175	1	0.2020785
No milfoil rake	Amiocentrus aspilus	3	CG	D	161	2	0.1859122
No milfoil rake	Vorticifex sp.	--	SC	D	110	3	0.1270208
No milfoil rake	Pseudocloeon sp.	--	CG	D	94	4	0.108545
No milfoil rake	Ostracoda	8	CG	D	69	5	0.0796767
No milfoil rake	Baetis sp.	5	CG	D	47	6	0.0542725
No milfoil rake	Isoperla sp.	2	P	D	45	7	0.051963
No milfoil rake	Ephemerella sp.	1	CG	D	37	8	0.0427252
No milfoil rake	Lepidostoma sp.	1	SH	D	27	9	0.0311778
No milfoil rake	Chironominae	6	CG	D	19	10	0.02194
No milfoil rake	Ferrissia sp.	6	SC	D	16	11	0.0184758
No milfoil rake	Orthocladiinae	5	CG	D	12	12	0.0138568
No milfoil rake	Tanypodinae	7	P	D	11	13	0.0127021
No milfoil rake	Physa sp.	8	SC	D	6	14	0.0069284

APPENDIX II: DOMINANT TAXA BY VEGETATION TYPE

Sample type	Taxon	Tol Val	FFG	Distinct	TOTAL	RANK	PERCENT
Z-grass rake	Fluminicola sp.	5	SC	D	192	1	0.2958398
Z-grass rake	Vorticifex sp.	--	SC	D	124	2	0.1910632
Z-grass rake	Baetis sp.	5	CG	D	96	3	0.1479199
Z-grass rake	Orthocladiinae	5	CG	D	33	4	0.0508475
Z-grass rake	Hyalella sp.	8	CG	D	31	5	0.0477658
Z-grass rake	Amiocentrus aspilus	3	CG	D	26	6	0.0400616
Z-grass rake	Ostracoda	8	CG	D	22	7	0.0338983
Z-grass rake	Ephemerella sp.	1	CG	D	20	8	0.0308166
Z-grass rake	Hydroptilidae	4	PH	N/D	18	9	0.027735
Z-grass sweep	Fluminicola sp.	5	SC	D	184	1	0.4
Z-grass sweep	Baetis sp.	5	CG	D	86	2	0.1869565
Z-grass sweep	Ostracoda	8	CG	D	47	3	0.1021739
Z-grass sweep	Vorticifex sp.	--	SC	D	42	4	0.0913043
Z-grass sweep	Ephemerella sp.	1	CG	D	35	5	0.076087
Z-grass sweep	Pseudocloeon sp.	--	CG	D	18	6	0.0391304
Z-grass sweep	Hydroptila sp.	6	PH	D	13	7	0.0282609
Z-grass sweep	Hygrobates sp.	8	P	D	9	8	0.0195652
Z-grass combined	Fluminicola sp.	5	SC	D	376	1	0.3390442
Z-grass combined	Baetis sp.	5	CG	D	182	2	0.1641118
Z-grass combined	Vorticifex sp.	--	SC	D	166	3	0.1496844
Z-grass combined	Ostracoda	8	CG	D	69	4	0.0622182
Z-grass combined	Ephemerella sp.	1	CG	D	55	5	0.0495942
Z-grass combined	Orthocladiinae	5	CG	D	37	6	0.0333634
Z-grass combined	Hyalella sp.	8	CG	D	35	7	0.03156

APPENDIX III: DOMINANT TAXA BY CHANNEL CROSS SECTION

Channel Cross Section	Taxon	Tol Val	FFG	Distinct	TOTAL	RANK	PERCENT
CCS 001	Valvata sp.	8	SC	D	153	1	0.51
CCS 001	Gyraulus sp.	8	SC	D	43	2	0.1433333
CCS 001	Chironominae	6	CG	D	37	3	0.1233333
CCS 001	Helisoma sp.	6	SC	D	17	4	0.0566667
CCS 002	Oligochaeta	5	CG	D	110	1	0.3583062
CCS 002	Fluminicola sp.	5	SC	D	82	2	0.267101
CCS 002	Hyalella sp.	8	CG	D	17	3	0.0553746
CCS 003	Ephemerella sp.	1	CG	D	185	1	0.6166667
CCS 003	Hyalella sp.	8	CG	D	28	2	0.0933333
CCS 004	Fluminicola sp.	5	SC	D	52	1	0.1733333
CCS 004	Ostracoda	8	CG	D	47	2	0.1566667
CCS 004	Oligochaeta	5	CG	D	37	3	0.1233333
CCS 004	Sphaeriidae	8	CG	D	25	4	0.0833333
CCS 004	Hyalella sp.	8	CG	D	24	5	0.08
CCS 004	Helisoma sp.	6	SC	D	24	6	0.08
CCS 004	Ephemerella sp.	1	CG	D	22	7	0.0733333
CCS 004	Vorticifex sp.	--	SC	D	20	8	0.0666667
CCS 004	Tanypodinae	7	P	D	19	9	0.0633333
CCS 004	Prodiamesinae	6	CG	D	7	10	0.0233333
CCS 004	Physa sp.	8	SC	D	4	11	0.0133333
CCS 004	Caecidotea sp.	8	CG	D	4	12	0.0133333
CCS 004	Platyhelminthes	--	--	D	3	13	0.01
CCS 004	Amiocentrus aspilus	3	CG	D	2	14	0.0066667
CCS 004	Lepidostoma sp.	1	SH	D	2	15	0.0066667
CCS 004	Gumaga sp.	3	SH	D	2	16	0.0066667

APPENDIX III: DOMINANT TAXA BY CHANNEL CROSS SECTION

Channel Cross Section	Taxon	Tol Val	FFG	Distinct	TOTAL	RANK	PERCENT
CCS 005	Oligochaeta	5	CG	D	101	1	0.3389262
CCS 005	Valvata sp.	8	SC	D	39	2	0.1308725
CCS 005	Vorticifex sp.	--	SC	D	29	3	0.0973154
CCS 005	Sphaeriidae	8	CG	D	29	4	0.0973154
CCS 005	Fluminicola sp.	5	SC	D	25	5	0.0838926
CCS 005	Hyalella sp.	8	CG	D	17	6	0.057047
CCS 005	Chironominae	6	CG	D	12	7	0.0402685
CCS 005	Helobdella sp.	6	PA	D	8	8	0.0268456
CCS 005	Gyraulus sp.	8	SC	D	7	9	0.0234899
CCS 005	Manayunkia speciosa	--	CF	D	6	10	0.0201342
CCS006	Sphaeriidae	8	CG	D	113	1	0.3766667
CCS006	Oligochaeta	5	CG	D	46	2	0.1533333
CCS006	Fluminicola sp.	5	SC	D	35	3	0.1166667
CCS006	Chironominae	6	CG	D	24	4	0.08
CCS006	Hyalella sp.	8	CG	D	16	5	0.0533333
CCS006	Tricorythodes sp.	4	CG	D	16	6	0.0533333
CCS006	Valvata sp.	8	SC	D	15	7	0.05
CCS006	Vorticifex sp.	--	SC	D	7	8	0.0233333
CCS006	Manayunkia speciosa	--	CF	D	7	9	0.0233333
CCS006	Hydroptila sp.	6	PH	D	6	10	0.02
CCS007	Oligochaeta	5	CG	D	100	1	0.3344482
CCS007	Fluminicola sp.	5	SC	D	65	2	0.2173913
CCS007	Hyalella sp.	8	CG	D	32	3	0.1070234
CCS007	Sphaeriidae	8	CG	D	15	4	0.0501672
CCS008	Fluminicola sp.	5	SC	D	115	1	0.3833333
CCS008	Oligochaeta	5	CG	D	68	2	0.2266667
CCS008	Hyalella sp.	8	CG	D	35	3	0.1166667
CCS008	Sphaeriidae	8	CG	D	19	4	0.0633333
CCS008	Agraylea sp.	8	PH	D	11	5	0.0366667
CCS008	Chironominae	6	CG	D	9	6	0.03

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances								Little Tule River	Fall River	Fall River	Fall River	Fall River
								CCS 001	CCS 002	CCS 003	CCS 004	CCS 005
								11/7/2005	11/8/2005	11/9/2005	11/9/2005	11/10/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon	Ponar Grab	Ponar Grab	Ponar Grab	Ponar Grab	Ponar Grab
Arthropoda												
			Coleoptera									
				Dytiscidae								
							Agabus sp.	--	--	--	1	--
				Elmidae								
							Dubiraphia sp.	--	--	--	--	--
							Optioservus sp.	--	--	--	--	--
				Haliplidae								
							Brychius sp.	--	--	--	--	--
							Haliplus sp.	--	--	--	--	1
			Diptera									
				Chironomidae								
					Chironominae			37	2	--	--	12
					Orthocladiinae			8	--	--	--	--
					Prodiamesinae			--	2	8	7	1
					Tanypodinae			4	4	17	19	4
				Empididae								
							Chelifera sp.	--	--	1	--	--
				Simuliidae								
							Simulium sp.	--	--	--	--	--
			Ephemeroptera									
				Baetidae				--	--	--	--	--
							Baetis sp.	--	1	1	--	--
							Centroptilum sp.	--	--	--	--	--
							Pseudocloeon sp.	--	1	--	--	--
				Caenidae								
							Caenis sp.	--	--	--	--	2
				Ephemerellidae				--	--	--	--	--
							Ephemerella sp.	--	13	185	22	--
							Drunella spinifera	--	--	--	--	--
				Ephemeridae								
							Hexagenia limbata	--	--	--	--	--
				Heptageniidae				--	--	1	--	--
				Leptohyphidae								
							Tricorythodes sp.	--	--	--	--	3

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances									Little Tule River	Fall River	Fall River	Fall River	Fall River
									CCS 001	CCS 002	CCS 003	CCS 004	CCS 005
									11/7/2005	11/8/2005	11/9/2005	11/9/2005	11/10/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon		Ponar Grab	Ponar Grab	Ponar Grab	Ponar Grab	Ponar Grab
				Leptophlebiidae									
							Paraleptophlebia sp.		--	--	--	--	--
			Hemiptera										
				Corixidae									
							Trichocorixa sp.		1	--	--	--	--
			Odonata										
				Aeshnidae					--	--	--	--	--
				Coenagrionidae					--	--	--	--	1
			Plecoptera										
				Leuctridae					--	--	--	1	--
				Perlodidae									
							Isoperla sp.		--	--	--	1	--
			Trichoptera						--	--	--	--	--
				Brachycentridae									
							Amiocentrus aspilus		--	--	--	2	--
				Hydroptilidae					--	--	--	--	1
							Agraylea sp.		--	--	--	--	--
							Hydroptila sp.		2	18	3	1	2
							Oxyethira sp.		--	--	--	--	--
				Lepidostomatidae					--	--	--	--	--
							Lepidostoma sp.		--	--	--	2	--
				Leptoceridae					--	--	--	--	--
							Mystacides sp.		--	--	--	--	--
							Oecetis sp.		--	--	--	--	--
				Sericostomatidae									
							Gumaga sp.		--	--	--	2	--
	Crustacea												
			Amphipoda						--	--	--	--	--
				Gammaridae									
							Gammarus sp.		--	--	--	--	--
				Hyalellidae									
							Hyalella sp.		2	17	28	24	17
			Isopoda										
				Asellidae									
							Caecidotea sp.		--	1	--	4	--

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances									Little Tule River	Fall River	Fall River	Fall River	Fall River
									CCS 001	CCS 002	CCS 003	CCS 004	CCS 005
									11/7/2005	11/8/2005	11/9/2005	11/9/2005	11/10/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon		Ponar Grab	Ponar Grab	Ponar Grab	Ponar Grab	Ponar Grab
		Ostracoda							1	5	--	47	1
	Chelicerata												
							Acari		--	--	1	--	--
			Trombidiformes										
				Hygrobatidae									
							Atractides sp.		--	--	--	--	--
							Hygrobates sp.		--	3	--	--	--
				Lebertiidae									
							Lebertia sp.		--	1	--	--	--
				Limnesiidae									
							Limnesia sp.		--	--	--	--	--
				Pionidae					--	--	--	--	--
Annelida													
	Aclitellata												
		Polychaeta											
			Canalipalpata										
				Sabellidae									
							Manayunkia speciosa		--	13	--	--	6
	Clitellata												
		Hirudinea							--	--	1	--	--
			Arhynchobdellida										
				Erpobdellidae					--	--	--	--	2
							Erpobdella sp.		--	1	--	--	--
			Rhynchobdellida										
				Glossiphoniidae					7	--	--	--	--
							Alboglossiphonia sp.		--	--	--	--	--
							Helobdella sp.		--	8	--	--	8
		Oligochaeta							10	110	15	37	101
Coelenterata													
		Hydrozoa											
			Hydroida										
				Hydridae									
							Hydra sp.		--	--	--	--	--
Mollusca													
		Bivalvia											

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances									Little Tule River	Fall River	Fall River	Fall River	Fall River
									CCS 001	CCS 002	CCS 003	CCS 004	CCS 005
									11/7/2005	11/8/2005	11/9/2005	11/9/2005	11/10/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon		Ponar Grab	Ponar Grab	Ponar Grab	Ponar Grab	Ponar Grab
			Veneroida										
				Sphaeriidae					1	1	3	25	29
		Gastropoda							9	--	1	--	--
			Basommatophora										
				Ancylidae									
							Ferrissia sp.		--	--	--	--	--
				Lymnaeidae					2	--	--	--	--
				Physidae									
							Physa sp.		1	--	1	4	--
				Planorbidae					--	--	--	--	1
							Gyraulus sp.		43	--	--	--	7
							Helisoma sp.		17	--	15	24	4
							Vorticifex sp.		--	7	4	20	29
			Heterostropha										
				Valvatidae									
							Valvata sp.		153	8	--	1	39
			Neotaenioglossa										
				Hydrobiidae									
							Fluminicola sp.		1	82	15	52	25
				Pleuroceridae									
							Juga sp.		--	8	--	1	--
Platyhelminthes									1	1	--	3	2
			Total invertebrates						300	307	300	300	298

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances									Fall River	Fall River	Fall River	Fall River	Fall River	Fall River
									CCS 007	CCS 008	Vineyard	Downstream Wilsons	Zugbug	CHARINB0(
									11/11/2005	11/11/2005	11/8/2005	11/11/2005	11/8/2005	11/10/20(
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon		Ponar Grab	Ponar Grab	Z Grass rake	Chara rake	Z grass rake	Chara rake
Arthropoda														
			Coleoptera											
				Dytiscidae										
							Agabus sp.		--	--	--	--	--	--
				Elmidae										
							Dubiraphia sp.		--	--	--	--	--	--
							Optioservus sp.		--	--	--	--	--	--
				Haliplidae										
							Brychius sp.		1	--	--	--	--	--
							Haliplus sp.		1	1	--	--	--	--
			Diptera											
				Chironomidae										
					Chironominae				4	9	1	--	--	--
					Orthocladiinae				1	1	8	--	4	
					Prodiamesinae				--	--	--	--	--	--
					Tanypodinae				5	3	--	--	--	--
				Empididae										
							Chelifera sp.		--	--	--	--	--	--
				Simuliidae										
							Simulium sp.		--	--	1	--	--	--
			Ephemeroptera											
				Baetidae					--	--	2	1	--	--
							Baetis sp.		--	--	35	6	28	1
							Centroptilum sp.		--	--	--	--	--	--
							Pseudocloeon sp.		--	--	1	--	7	--
				Caenidae										
							Caenis sp.		5	1	--	--	--	--
				Ephemerellidae					--	--	5	11	--	--
							Ephemerella sp.		--	--	2	2	6	7
							Drunella spinifera		--	--	--	--	--	--
				Ephemeridae										
							Hexagenia limbata		--	--	--	--	--	--
				Heptageniidae					--	--	--	--	--	--
				Leptohyphidae										
							Tricorythodes sp.		--	--	--	--	--	--

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances									Fall River	Fall River	Fall River	Fall River	Fall River	Fall
									CCS 007	CCS 008	Vineyard	Downstream Wilsons	Zugbug	CHARINB0
									11/11/2005	11/11/2005	11/8/2005	11/11/2005	11/8/2005	11/10/200
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon		Ponar Grab	Ponar Grab	Z Grass rake	Chara rake	Z grass rake	Chara rak
				Leptophlebiidae										
							Paraleptophlebia sp.		--	--	--	--	--	--
			Hemiptera											
				Corixidae										
							Trichocorixa sp.		--	--	--	--	--	--
			Odonata											
				Aeshnidae					1	--	--	--	--	--
				Coenagrionidae					10	9	--	2	--	--
			Plecoptera											
				Leuctridae					--	--	--	--	--	--
				Perlodidae										
							Isoperla sp.		--	--	3	--	2	--
			Trichoptera						--	--	--	--	--	--
				Brachycentridae										
							Amiocentrus aspilus		--	--	7	1	15	--
				Hydroptilidae					--	--	1	1	15	--
							Agraylea sp.		--	11	--	--	--	--
							Hydroptila sp.		--	1	1	15	10	8
							Oxyethira sp.		--	--	--	--	--	--
				Lepidostomatidae					--	--	--	1	--	--
							Lepidostoma sp.		--	--	--	--	--	--
				Leptoceridae					--	--	--	--	--	--
							Mystacides sp.		1	1	--	2	--	
							Oecetis sp.		1	--	--	--	--	--
				Sericostomatidae										
							Gumaga sp.		--	--	--	--	--	--
	Crustacea													
			Amphipoda						--	--	--	2	--	--
				Gammaridae										
							Gammarus sp.		--	--	--	11	--	
				Hyalellidae										
							Hyalella sp.		32	35	13	37	--	
			Isopoda											
				Asellidae										
							Caecidotea sp.		1	--	2	--	--	--

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances								Fall River	Fall River	Fall River	Fall River	Fall River	Fall River
								CCS 007	CCS 008	Vineyard	Downstream Wilsons	Zugbug	CHARINB00
								11/11/2005	11/11/2005	11/8/2005	11/11/2005	11/8/2005	11/10/200
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon	Ponar Grab	Ponar Grab	Z Grass rake	Chara rake	Z grass rake	Chara rake
		Ostracoda						5	--	1	2	18	1
	Chelicerata												
							Acari	--	--	--	--	--	--
			Trombidiformes										
				Hygrobatidae									
							Atractides sp.	--	--	--	--	--	--
							Hygrobates sp.	--	--	--	--	--	--
				Lebertiidae									
							Lebertia sp.	--	--	--	--	--	--
				Limnesiidae									
							Limnesia sp.	--	--	--	--	--	1
				Pionidae				--	--	--	--	--	--
Annelida													
	Aclitellata												
		Polychaeta											
			Canalipalpata										
				Sabellidae									
							Manayunkia speciosa	--	--	--	--	--	--
	Clitellata												
		Hirudinea						--	--	--	--	--	--
			Arhynchobdellida										
				Erpobdellidae				--	--	--	--	--	--
							Erpobdella sp.	1	4	1	--	--	--
			Rhynchobdellida										
				Glossiphoniidae				--	--	--	--	--	--
							Alboglossiphonia sp.	--	--	--	--	--	--
							Helobdella sp.	13	8	2	--	--	--
		Oligochaeta						100	68	2	1	--	--
Coelenterata													
		Hydrozoa											
			Hydroida										
				Hydridae									
							Hydra sp.	--	--	--	--	--	--
Mollusca													
		Bivalvia											

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances								Fall River	Fall River	Fall River	Fall River	Fall River	Fall
								CCS 007	CCS 008	Vineyard	Downstream Wilsons	Zugbug	CHARINB0
								11/11/2005	11/11/2005	11/8/2005	11/11/2005	11/8/2005	11/10/20
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon	Ponar Grab	Ponar Grab	Z Grass rake	Chara rake	Z grass rake	Chara rak
			Veneroida										
				Sphaeriidae				15	19	--	--	--	--
		Gastropoda						1	--	1	--	1	
			Basommatophora										
				Ancylidae									
							Ferrissia sp.	--	--	--	--	--	--
				Lymnaeidae				--	--	--	--	--	--
				Physidae									
							Physa sp.	7	1	1	--	--	--
				Planorbidae				1	--	--	--	--	--
							Gyraulus sp.	7	1	--	--	--	
							Helisoma sp.	1	1	--	--	--	--
							Vorticifex sp.	13	2	5	5	115	
			Heterostropha										
				Valvatidae									
							Valvata sp.	7	--	--	--	--	--
			Neotaenioglossa										
				Hydrobiidae									
							Fluminicola sp.	65	115	36	200	79	12
				Pleuroceridae									
							Juga sp.	--	--	--	--	--	--
Platyhelminthes								--	9	--	--	--	--
Total invertebrates								299	300	131	300	300	30

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances									Fall River	Fall River	Fall River	Fall River	Fall River
									Danford Bridge	Wilsons	CCS 008	Fall River Ranch	Sportsman
									11/10/2005	11/10/2005	11/11/2005	11/9/2005	11/9/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon		Chara rake	Z grass rake	E milfoil rake	No milfoil rake	No milfoil rake
Arthropoda													
			Coleoptera										
				Dytiscidae									
							Agabus sp.		3	--	--	--	--
				Elmidae									
							Dubiraphia sp.		--	--	--	--	--
							Optioservus sp.		--	--	--	1	--
				Haliplidae									
							Brychius sp.		--	--	--	--	--
							Haliplus sp.		--	--	--	--	--
			Diptera										
				Chironomidae									
					Chironominae				2	1	80	8	8
					Orthocladiinae				--	21	51	3	6
					Prodiamesinae				--	--	--	--	--
					Tanypodinae				--	2	2	4	5
				Empididae									
							Chelifera sp.		--	--	--	--	--
				Simuliidae									
							Simulium sp.		--	2	--	--	--
			Ephemeroptera										
				Baetidae					--	2	1	--	--
							Baetis sp.		2	33	--	10	23
							Centroptilum sp.		--	1	--	--	--
							Pseudocloeon sp.		--	--	--	39	12
				Caenidae									
							Caenis sp.		--	--	--	--	--
				Ephemerellidae					--	3	--	--	--
							Ephemerella sp.		18	12	--	11	6
							Drunella spinifera		--	--	--	1	--
				Ephemeridae									
							Hexagenia limbata		--	--	--	--	--
				Heptageniidae					--	--	--	--	--
				Leptohyphidae									
							Tricorythodes sp.		--	1	--	--	--

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances									Fall River	Fall River	Fall River	Fall River	Fall River
									Danford Bridge	Wilsons	CCS 008	Fall River Ranch	Sportsman
									11/10/2005	11/10/2005	11/11/2005	11/9/2005	11/9/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon		Chara rake	Z grass rake	E milfoil rake	No milfoil rake	No milfoil rake
				Leptophlebiidae									
							Paraleptophlebia sp.		--	--	--	--	--
			Hemiptera										
				Corixidae									
							Trichocorixa sp.		--	--	--	--	--
			Odonata										
				Aeshnidae					--	--	--	--	--
				Coenagrionidae					--	--	8	--	--
			Plecoptera										
				Leuctridae					--	--	--	--	1
				Perlodidae									
							Isoperla sp.		--	--	--	18	7
			Trichoptera						--	--	--	--	--
				Brachycentridae									
							Amiocentrus aspilus		4	4	1	67	67
				Hydroptilidae					20	2	3	--	--
							Agraylea sp.		--	--	2	--	--
							Hydroptila sp.		1	6	--	2	--
							Oxyethira sp.		--	--	30	--	--
				Lepidostomatidae					--	--	--	--	--
							Lepidostoma sp.		--	--	--	21	3
				Leptoceridae					--	--	--	--	--
							Mystacides sp.		1	--	--	--	--
							Oecetis sp.		--	--	--	--	--
				Sericostomatidae									
							Gumaga sp.		--	--	--	--	--
	Crustacea												
			Amphipoda						--	--	--	--	--
				Gammaridae									
							Gammarus sp.		6	10	--	--	--
				Hyalellidae									
							Hyalella sp.		8	18	57	--	--
			Isopoda										
				Asellidae									
							Caecidotea sp.		13	--	--	--	--

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances								Fall River	Fall River	Fall River	Fall River	Fall River
								Danford Bridge	Wilsons	CCS 008	Fall River Ranch	Sportsman
								11/10/2005	11/10/2005	11/11/2005	11/9/2005	11/9/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon	Chara rake	Z grass rake	E milfoil rake	No milfoil rake	No milfoil rake
		Ostracoda						22	3	1	3	4
	Chelicerata											
							Acari	--	--	--	--	--
			Trombidiformes									
				Hygrobatidae								
							Atractides sp.	--	--	--	--	3
							Hygrobates sp.	--	--	--	--	--
				Lebertiidae								
							Lebertia sp.	--	1	--	--	--
				Limnesiidae								
							Limnesia sp.	--	--	--	--	--
				Pionidae				--	--	--	--	--
Annelida												
	Aclitellata											
		Polychaeta										
			Canalipalpata									
				Sabellidae								
							Manayunkia speciosa	--	--	--	--	--
	Clitellata											
		Hirudinea						--	--	--	--	--
			Arhynchobdellida									
				Erpobdellidae				--	--	--	--	--
							Erpobdella sp.	--	--	--	--	--
			Rhynchobdellida									
				Glossiphoniidae				--	--	--	--	--
							Alboglossiphonia sp.	2	--	--	--	--
							Helobdella sp.	--	1	--	--	--
		Oligochaeta						--	14	5	4	--
Coelenterata												
		Hydrozoa										
			Hydroida									
				Hydridae								
							Hydra sp.	--	--	1	--	--
Mollusca												
		Bivalvia										

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances								Fall River	Fall River	Fall River	Fall River	Fall River
								Danford Bridge	Wilsons	CCS 008	Fall River Ranch	Sportsman
								11/10/2005	11/10/2005	11/11/2005	11/9/2005	11/9/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon	Chara rake	Z grass rake	E milfoil rake	No milfoil rake	No milfoil rake
			Veneroida									
				Sphaeriidae				--	--	4	--	--
		Gastropoda						--	--	1	1	3
			Basommatophora									
				Ancylidae								
							Ferrissia sp.*	--	--	--	6	9
				Lymnaeidae				--	--	--	--	--
				Physidae								
							Physa sp.	1	--	8	1	--
				Planorbidae				--	--	--	--	--
							Gyraulus sp.	--	--	14	--	--
							Helisoma sp.	--	--	--	--	--
							Vorticifex sp.	5	4	6	21	49
			Heterostropha									
				Valvatidae								
							Valvata sp.	--	--	--	--	--
			Neotaenioglossa									
				Hydrobiidae								
							Fluminicola sp.	192	77	24	78	60
				Pleuroceridae								
							Juga sp.	--	--	--	1	--
Platyhelminthes								--	--	--	--	--
Total invertebrates								300	218	299	300	266

*There were taxonomic discrepancies between AEAL identification and ABL identification of *Ferrissia*. The ABL would report this taxa as *Lanx* The QC'd taxa was from the Fall River Ranch Bridge sample, but *Ferrissia* appeared the same across samples. In either case, there was only one distinct limpet or cap-shaped snail (gastropod) for all Fall River samples. Functional feeding metrics would change slightly, but diversity and taxonomic richness scores would remain unchanged.

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances								Fall River	Fall River	Fall River	Fall River	Fall River
								CCS 007	Vineyard	Whipple Bend	Zugbug	Vineyard
								11/11/2005	11/8/2005	11/9/2005	11/8/2005	11/8/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon	E milfoil rake	E milfoil rake	No milfoil rake	Z grass sweeps	Z grass sweep
Arthropoda												
			Coleoptera									
				Dytiscidae								
							Agabus sp.	--	--	--	--	--
				Elmidae								
							Dubiraphia sp.	1	--	--	--	--
							Optioservus sp.	--	--	--	--	--
				Haliplidae								
							Brychius sp.	--	1	1	--	--
							Haliplus sp.	1	--	--	--	--
			Diptera									
				Chironomidae								
					Chironominae			105	10	3	--	--
					Orthocladiinae			59	30	3	4	--
					Prodiamesinae			--	--	--	--	--
					Tanypodinae			7	11	2	--	--
				Empididae								
							Chelifera sp.	--	--	--	--	--
				Simuliidae								
							Simulium sp.	2	--	--	--	--
			Ephemeroptera									
				Baetidae				--	1	--	--	--
							Baetis sp.	2	32	14	43	43
							Centroptilum sp.	--	10	--	2	--
							Pseudocloeon sp.	--	2	43	10	8
				Caenidae								
							Caenis sp.	1	--	--	--	--
				Ephemerellidae				--	--	--	--	--
							Ephemerella sp.	--	22	20	12	23
							Drunella spinifera	--	--	--	--	--
				Ephemeridae								
							Hexagenia limbata	--	--	--	--	--
				Heptageniidae				--	--	--	--	--
				Leptohyphidae								
							Tricorythodes sp.	--	--	--	--	--

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances									Fall River CCS 007	Fall River Vineyard	Fall River Whipple Bend	Fall River Zugbug	Fall River Vineyard
									11/11/2005	11/8/2005	11/9/2005	11/8/2005	11/8/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon		E milfoil rake	E milfoil rake	No milfoil rake	Z grass sweeps	Z grass sweep
				Leptophlebiidae									
							Paraleptophlebia sp.		--	--	2	--	--
			Hemiptera										
				Corixidae									
							Trichocorixa sp.		--	--	--	--	--
			Odonata										
				Aeshnidae					--	--	--	--	--
				Coenagrionidae					4	1	1	--	--
			Plecoptera										
				Leuctridae					--	--	1	--	--
				Perlodidae									
							Isoperla sp.		--	--	20	2	--
			Trichoptera						--	--	--	1	--
				Brachycentridae									
							Amiocentrus aspilus		1	11	27	--	--
				Hydroptilidae					2	--	--	--	--
							Agraylea sp.		--	--	--	--	--
							Hydroptila sp.		11	66	1	13	--
							Oxyethira sp.		1	--	--	--	--
				Lepidostomatidae					--	--	--	--	--
							Lepidostoma sp.		--	3	3	--	1
				Leptoceridae					1	--	--	--	--
							Mystacides sp.		--	--	--	--	--
							Oecetis sp.		--	--	--	--	--
				Sericostomatidae									
							Gumaga sp.		--	--	--	--	--
	Crustacea												
			Amphipoda						--	--	--	--	--
				Gammaridae									
							Gammarus sp.		--	1	2	--	--
				Hyalellidae									
							Hyalella sp.		17	1	3	--	4
			Isopoda										
				Asellidae									
							Caecidotea sp.		1	1	--	--	1

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances								Fall River CCS 007	Fall River Vineyard	Fall River Whipple Bend	Fall River Zugbug	Fall River Vineyard
								11/11/2005	11/8/2005	11/9/2005	11/8/2005	11/8/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon	E milfoil rake	E milfoil rake	No milfoil rake	Z grass sweeps	Z grass sweep
		Ostracoda						--	2	62	30	17
	Chelicerata											
							Acari	--	--	1	--	--
			Trombidiformes									
				Hygrobatidae								
							Atractides sp.	--	--	1	1	2
							Hygrobates sp.	--	--	--	--	9
				Lebertiidae								
							Lebertia sp.	--	1	--	--	1
				Limnesiidae								
							Limnesia sp.	--	--	--	--	--
				Pionidae				--	--	--	--	--
Annelida												
	Aclitellata											
		Polychaeta										
			Canalipalpata									
				Sabellidae								
							Manayunkia speciosa	2	--	--	--	--
	Clitellata											
		Hirudinea						--	--	--	--	--
			Arhynchobdellida									
				Erpobdellidae				--	--	--	--	--
							Erpobdella sp.	--	--	--	--	--
			Rhynchobdellida									
				Glossiphoniidae				--	--	--	--	--
							Alboglossiphonia sp.	--	2	--	--	--
							Helobdella sp.	1	--	--	--	--
		Oligochaeta						7	35	1	--	--
Coelenterata												
		Hydrozoa										
			Hydroida									
				Hydridae								
							Hydra sp.	--	1	--	--	1
Mollusca												
		Bivalvia										

APPENDIX IV: FALL RIVER TAXA ABUNDANCES

Fall River Taxa Abundances								Fall River	Fall River	Fall River	Fall River	Fall River
								CCS 007	Vineyard	Whipple Bend	Zugbug	Vineyard
								11/11/2005	11/8/2005	11/9/2005	11/8/2005	11/8/2005
Phylum	Subphylum	Class	Order	Family	Subfamily	Tribe	Taxon	E milfoil rake	E milfoil rake	No milfoil rake	Z grass sweeps	Z grass sweep
			Veneroida									
				Sphaeriidae				1	--	3	--	--
		Gastropoda						5	--	--	1	--
			Basommatophora									
				Ancylidae								
							Ferrissia sp.*	--	--	1	--	--
				Lymnaeidae				--	--	--	--	--
				Physidae								
							Physa sp.	5	--	5	--	--
				Planorbidae				--	--	--	--	--
							Gyraulus sp.	12	--	--	--	--
							Helisoma sp.	--	--	2	--	--
							Vorticifex sp.	25	2	40	42	--
			Heterostropha									
				Valvatidae								
							Valvata sp.	--	2	1	--	--
			Neotaenioglossa									
				Hydrobiidae								
							Fluminicola sp.	26	50	37	139	45
				Pleuroceridae								
							Juga sp.	--	--	--	--	--
Platyhelminthes								--	2	--	--	5
Total invertebrates								300	300	300	300	160

*There were taxonomic discrepancies between AEAL identification and ABL identification of *Ferrissia*. The ABL would report this taxa as *Lanx* The QC'd taxa was from the Fall River Ranch Bridge sample, but *Ferrissia* appeared the same across samples. In either case, there was only one distinct limpet or cap-shaped snail (gastropod) for all Fall River samples. Functional feeding metrics would change slightly, but diversity and taxonomic richness scores would remain unchanged.

APPENDIX V: TRACEABLE DIGITAL OXYGEN METER CALIBRATION AND MEASUREMENT STANDARD OPERATING PROCEDURE

AEAL February 2005

Purpose: This standard operation procedure (SOP) provides a detailed description for the calibration of the Traceable digital dissolved oxygen meter manufactured by the Control Company of Friendswood, Texas for the Fisher Scientific Corporation.

Step 1: Calibration of meter:

1. Disconnect the **Oxygen Probe Plug** from the socket on top of the unit labeled **Input.**
2. Turn the meter on by switching the **Power** button to the right.
3. Select **O_2** by sliding the **O_2/DO** selector to this position.
4. Press the **Zero** button. The display will show **0.**
5. Connect the **Oxygen Probe Plug** to the socket on top of the unit labeled **Input.** Wait at least five minutes until the display values stabilize and no longer fluctuate.
6. Press the **O_2 Calibration** button. The display will show either 20.8 or 20.9, the typical oxygen percentage in the air.

Note: Calibrate the meter in a large, well ventilated environment for best results.

Step 2: Measurement of dissolved oxygen:

1. To measure dissolved oxygen, slide the **O_2/DO** selector to the **DO** position.

APPENDIX V: TRACEABLE DIGITAL OXYGEN METER CALIBRATION AND MEASUREMENT STANDARD OPERATING PROCEDURE

2. If measuring in a saline environment, it may be necessary to adjust the % salt compensation of the probe. To determine if this is necessary measure the saline content of the water using a salinity meter. If the salinity is 1% or greater press the **% Salt** button. The display will show an "S" for salinity, and 0%. Press the **Factor Adjustment** button once. This will add 1% to the original salt %. Continue pressing this button until it reaches the desired value. When complete, press the **% Salt** button.
3. If your measurement is not taking place at sea level, you will need to adjust the Height compensation. Press the **MT** button. The display will show an "H" for height and a "0" for sea level. Press the **Factor Adjustment** button once. This will add 100 meters. Continue pressing this button until the display has reached the desired value. When complete, press the **MT** button.
4. Immerse the probe at least 10cm into the liquid being measured. This ensures that the probe will measure the temperature of the liquid and the automatic temperature adjustment will take place. Allow a few minutes for the probe temperature to reach the temperature of the liquid. If there are more than a few degrees of difference between the temperature of the liquid and the probe, allow more time for the probe temperature to adapt.

APPENDIX V: TRACEABLE DIGITAL OXYGEN METER CALIBRATION AND MEASUREMENT STANDARD OPERATING PROCEDURE

5. To measure the dissolved oxygen content, the velocity of the liquid being measured must be at least 0.2-0.3 m/s. To achieve this, immerse the probe in the solution and gently shake it. To save the DO measurement on the display until it can be recorded to a field sheet press the **Hold** button. A "DH" will appear in the upper left portion of the display to indicate that the value is a "held" value. To cancel the data hold feature, press the **Hold** button a second time.
6. After use, rinse the probe thoroughly with tap water.

Replacing the electrolyte:

1. When the meter cannot be calibrated properly or if the reading is unstable, the electrolyte may need to be refilled or the diaphragm may be dirty and need to be replaced. Unscrew the electrolyte container from the electrode holder.
2. Pour out the old electrolyte from the electrolyte container.
3. Unscrew the electrolyte container from the probe head. Replace the diaphragm and fit onto the electrolyte container. Place the O-ring between the diaphragm and the probe head and reassemble.
4. Place approximately 3-5 drops of fresh electrolyte into the electrolyte container.
5. Reassemble the electrolyte container with the electrode holder.

APPENDIX V: TRACEABLE DIGITAL OXYGEN METER CALIBRATION AND MEASUREMENT STANDARD OPERATING PROCEDURE

Battery life:

If the letters "LBT" appear on the left corner of the display, it indicates the battery is low and needs to be replaced. To replace the battery, slide the battery cover on the back of the unit away from the unit. Remove the old battery and replace it with a new 9-Volt alkaline battery. Use an alkaline battery, NOT a regular or heavy duty battery. Properly connect the battery. Install the battery cover. Incorrectly installed batteries may damage the electronics.

Specifications:

Ranges:	Dissolved Oxygen	0 to 20.0 mg/L
	Oxygen in air	0 to 100% O_2
	Temperature	0 to 50° C
Resolution:	Dissolved Oxygen	0.1 mg/L
	Oxygen	0.1% O_2
	Temperature	0.1° C
Accuracy:	Dissolved Oxygen	± 0.4 mg/L
	Oxygen	± 0.7% O_2
	Temperature	± 0.8° C, ± 1.5° F

APPENDIX V: TRACEABLE DIGITAL OXYGEN METER CALIBRATION AND MEASUREMENT STANDARD OPERATING PROCEDURE

Probe compensation	Temperature:	0 to 50LC, automatic
and adjustment:	Salt:	0 to 39% salt
	Height:	0 to 3900 meters

APPENDIX VI: OAKTON PORTABLE WATERPROOF PH/CON 10 METER

CALIBRATION STANDARD OPERATING PROCEDURE

JMIE January 2004

Purpose: This standard operation procedure (SOP) provides a detailed description for the calibration of the OAKTON Portable Waterproof pH/CON 10 Meter (Model #35630-02)

Note: All calibrations used pH/conductivity/temperature probes designed for the OAKTON Portable Waterproof pH/CON 10 Meter (Model #35630-02) only.

Step 1: Reset pH and conductivity to the factory defaults.

To reset pH, make sure the meter is in pH mode, then:

1.) While in measurement mode, press CAL/MEAS and hold for 3 seconds.

2.) The meter will prompt RST in the upper display and CAL in the lower display.

3.) Press enter to reset the meter to its factory defaults. The screen will flash all characters, then return to measurement mode once the meter is reset.

To reset conductivity, make sure the meter is in conductivity mode, and then follow steps 1-3 above.

APPENDIX VI: OAKTON PORTABLE WATERPROOF PH/CON 10 METER

CALIBRATION STANDARD OPERATING PROCEDURE

Step 2: Preparing the pH/CON meter for calibration.

1.) Remove the protective rubber cap of the probe before calibration.

2.) Wet the probe in tap water for 10 minutes before calibrating or taking readings to saturate the pH electrode surface and minimize drift.

Step 3: 3-point (OAKTON pH 4.00, 7.00 and 10.00) pH calibration.

1.) If necessary, press the MODE key to select pH mode. The pH indicator appears in the upper right hand corner of the display.

2.) Rinse the probe thoroughly with de-ionized water or a rinse solution. Do not wipe the probe; this causes a build-up of electrostatic charge on the glass surface.

3.) Dip the probe into the calibration buffer. The end of the probe must be completely immersed into the sample. Stir the probe gently to create a homogenous sample.

4.) Wait for the measured pH value to stabilize. The READY indicator will display when the reading stabilizes.

5.) Press CAL/MEAS to enter pH calibration mode. The primary display will show the measured reading, while the smaller secondary display will indicate the pH standard buffer solution. Scroll up or down until the secondary display value is the same as the pH buffer value you are using (pH 4.00, 7.00 or 10.00).

APPENDIX VI: OAKTON PORTABLE WATERPROOF PH/CON 10 METER CALIBRATION STANDARD OPERATING PROCEDURE

6.) Wait for the measured pH value to stabilize. The READY indicator will display when the reading stabilizes.

7.) After the READY indicator turns on, press ENTER to confirm calibration. A confirming indicator (CON) flashes and disappears. The meter is now calibrated at the buffer indicated in the secondary display.

8.) The secondary display automatically scrolls to the next buffer calibration option. Scroll up or down to select the next buffer value you want to calibrate (pH 4.00, 7.00 or 10.00).

9.) Rinse the probe with de-ionized water or a rinse solution, and place it in the next pH buffer.

10.) Follow steps 5-8 for additional calibration points.

11.) When calibration is complete, press CAL/MEAS to return to pH measurement mode.

Note: If the selected buffer value is not within +/-1.00 pH from the measured value: the electrode and buffer icon blink and the ERR annunciator appears in the lower left corner of the display. These indicators also flash if the buffer used in not the same as the buffer value on the secondary display.

APPENDIX VI: OAKTON PORTABLE WATERPROOF PH/CON 10 METER CALIBRATION STANDARD OPERATING PROCEDURE

Step 4: Conductivity Calibration

1.) Pour out two separate portions of the calibration standard and one of deionized water into separate clean containers. Choose a calibration solution value that is approximately 2/3 the full-scale value of the measurement range (e.g. in the 0 to 1999 µS range, use a 1413 µS solution for calibration). A 447 µS standard solution is generally adequate in this study.

2.) If necessary, press the MODE key to select the Conductivity Mode. The µS or mS indicator will appear on the right side of the display.

3.) Rinse your probe with deionized water, then rinse the probe in one of the portions of calibration standard.

4.) Immerse the probe into the second portion of calibration standard. The meter's autoranging function selects the appropriate conductivity range (four ranges are possible). Be sure to tap the probe to remove air bubbles. Air bubbles will cause errors in calibration.

5.) Wait for the reading to stabilize. The READY indicator lights when the reading is stable.

6.) Press the CAL/MEAS key. The CAL indicator appears above the primary display. The primary display shows the factory default and the secondary display shows the temperature.

APPENDIX VI: OAKTON PORTABLE WATERPROOF PH/CON 10 METER CALIBRATION STANDARD OPERATING PROCEDURE

7.) Scroll up or down to the value of your conductivity standard. Press and hold the scroll keys to go faster. The meter automatically compensates for temperatures using a factor of 2.00% per C.

8.) Press the ENTER key to confirm calibration. Upon calibration, the CON indicator appears briefly. The meter automatically switches back into Measurement mode. The display now shows the calibrated, temperature compensated conductivity value.

9.) For calibration in other ranges (Maximum: 4 ranges) repeat steps 1 through 9 with the appropriate calibration standards.

Note: if the calibration value input into the meter is different from the factory default value displayed by more than 30%, the ERR annunciator appears in the lower left corner of the display. Clean probe with alcohol. Verify that your calibration standard is fresh and accurate.

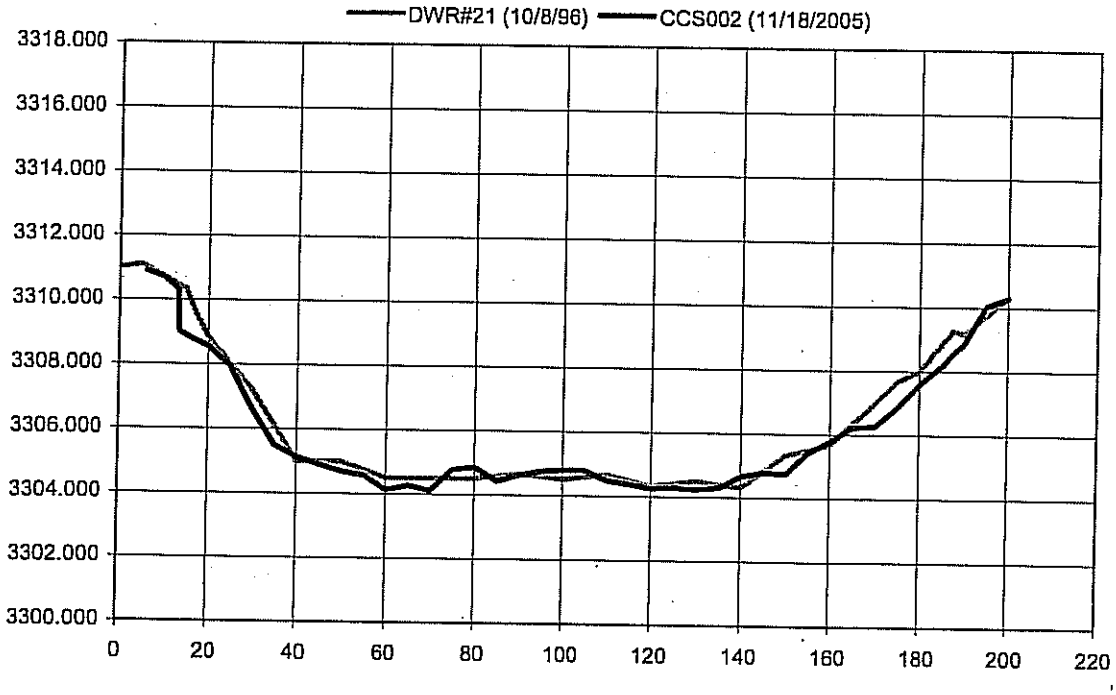
Step 5: Calibration Documentation

1.) After calibrating a meter for pH and conductivity, the person who calibrated the meter will record the date, which calibrations were made and their initials on a decal affixed to the inside of the meter case.

*Steps were transposed from the OAKTON Portable Waterproof pH/CON 10 Meter (Model #35630-02) manual of operating instructions (68X230403 rev2 01 / 02)

APPENDIX VII: COMPARISONS OF CROSS SECTION SURVEYS BY UC DAVIS, DWR, TETRATECH, SHN, AND FRWTF

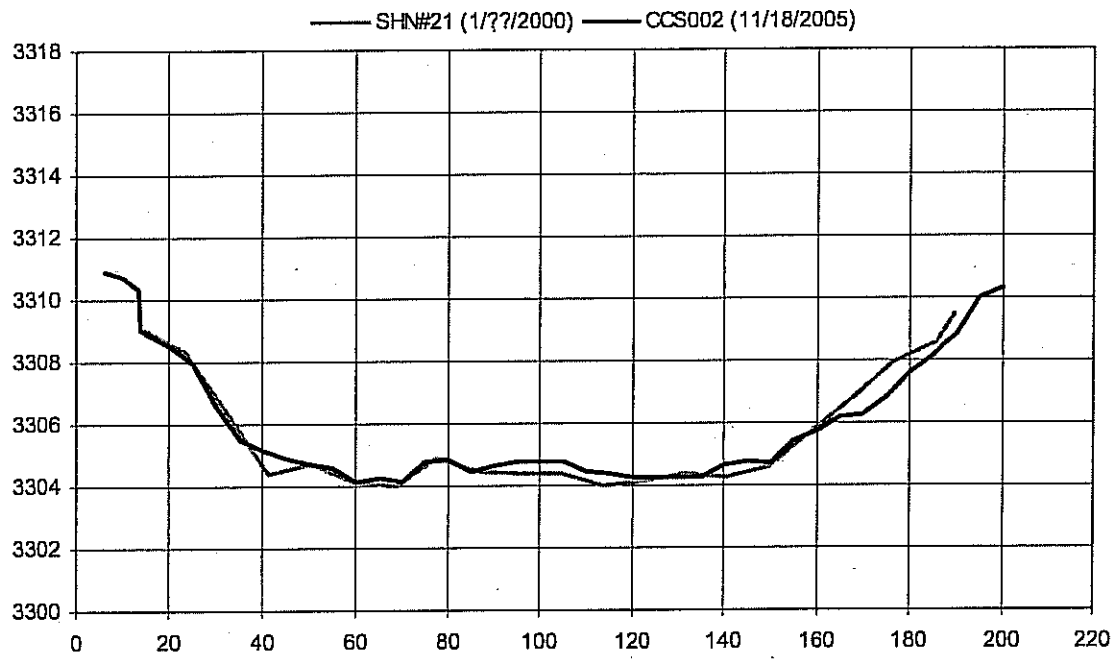
Cross Section Survey Comparison between DWR#21 and CCS002



Cross section CCS002 exhibited a net loss of sediment totaling 27.9 ft^2 in the UC Davis survey of 18 November 2005 compared to the DWR survey of the same cross section on 8 October 1996 (calculated using a water surface elevation of 3309 ft). Scouring was limited mainly to the banks of the channel. Along the bottom of the channel there were a few places that accrued small sediment deposits as well as areas where the channel was slightly scoured.

APPENDIX VII: COMPARISONS OF CROSS SECTION SURVEYS BY UC DAVIS, DWR, TETRATECH, SHN, AND FRWTF

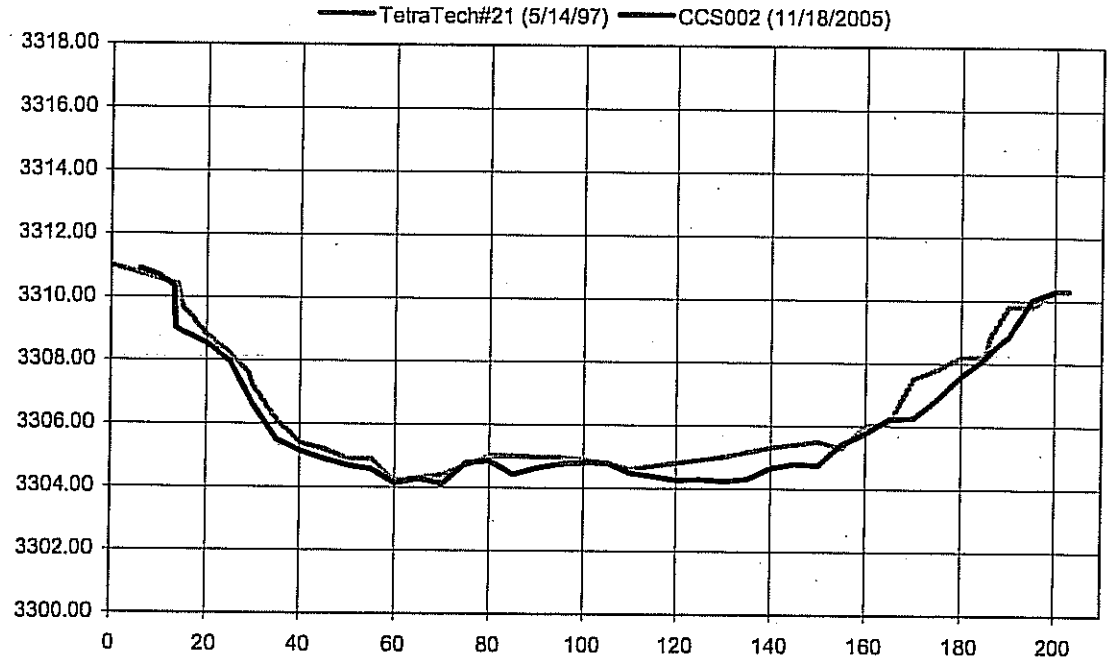
Cross Section Survey Comparison between SHN#21 and CCS002



Cross section CCS002 had a net gain of 2.5 ft^2 of sediment from the SHN survey in January of 2000 to the UC Davis survey of 18 November 2005 (calculated using a water surface elevation 3309 ft). On the left bank, both surveys found the channel to be almost identical. Along the bottom of the channel there was mostly deposition, and on the right bank there was mostly scouring.

APPENDIX VII: COMPARISONS OF CROSS SECTION SURVEYS BY UC DAVIS, DWR, TETRATECH, SHN, AND FRWTF

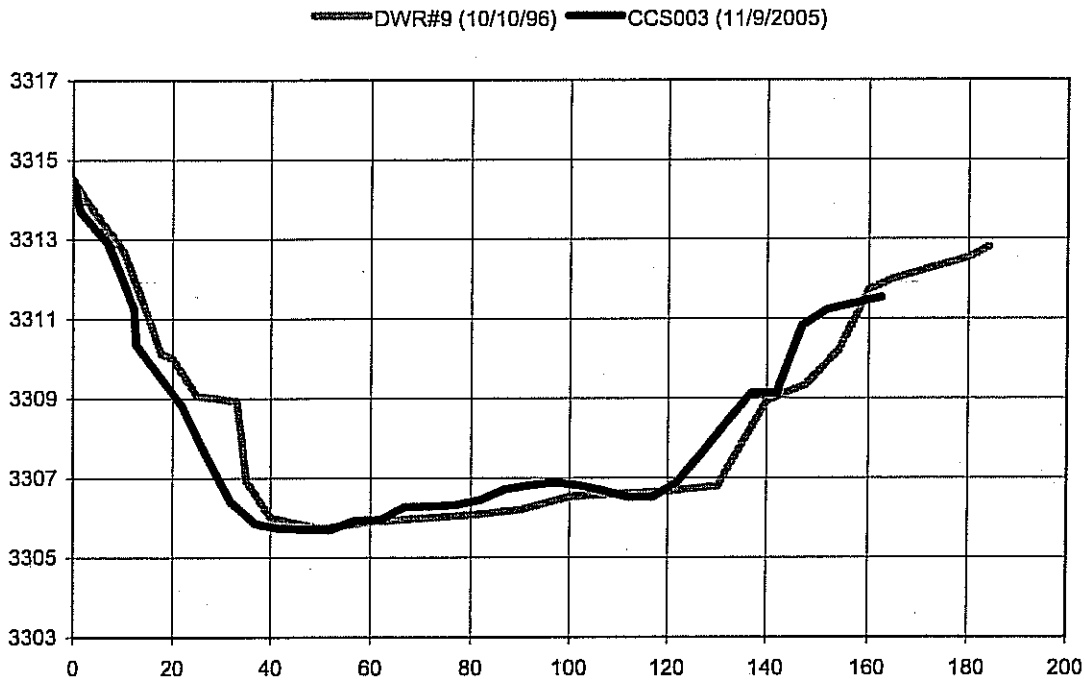
Cross Section Survey Comparison between TetraTech#21 and CCS002



Over the course of eight years between the Tetra Tech survey of 14 May 1997 and the UC Davis survey of 18 November 2005, there was a net scouring in the cross sectional area of 63.9 ft^2 (calculated using a water surface elevation of 3309 ft). The majority of the scouring occurred on the banks, especially the right bank and a portion of the right side of the river bottom. Throughout most of the cross section, the scouring was small but consistent, with no areas of deposition.

APPENDIX VII: COMPARISONS OF CROSS SECTION SURVEYS BY UC DAVIS, DWR, TETRATECH, SHN, AND FRWTF

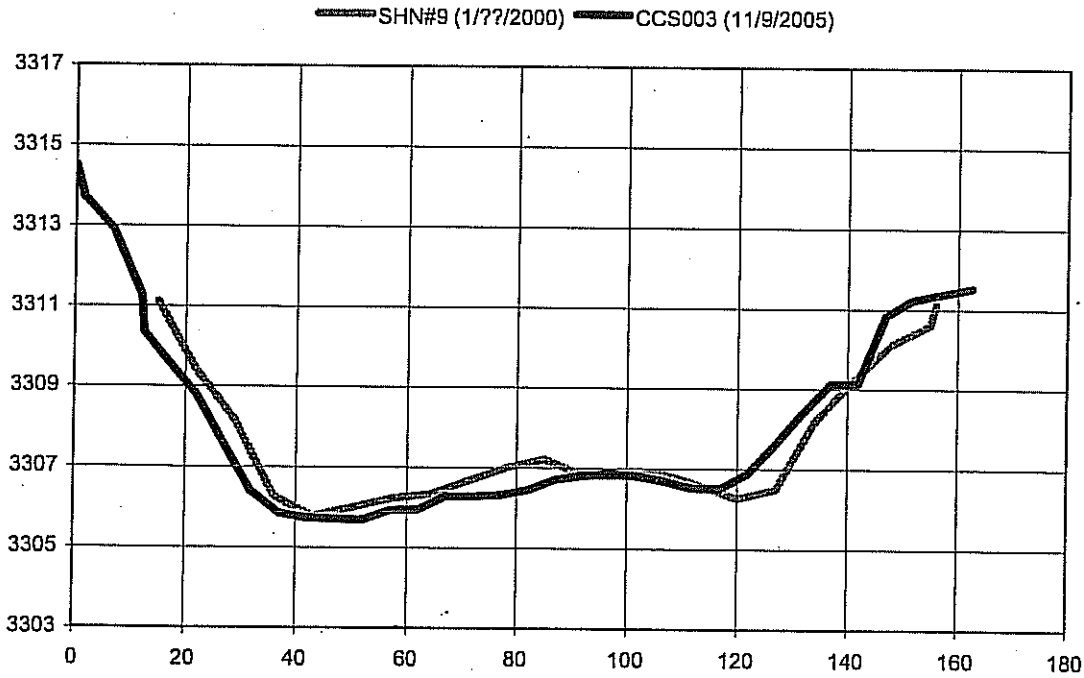
Cross Section Survey Comparison between DWR#9 and CCS003



During a nine year period between the DWR survey on 10 October 1996 and the UC Davis survey on 9 November 2005, cross section CCS003 experienced a net loss of sediment of 12 ft^2 (calculated using a water surface elevation of 3309 ft). Scouring occurred on both banks of the channel. Along the bottom there were areas where no visible change to the channel occurred and a section in the middle bottom where there was sediment deposition.

APPENDIX VII: COMPARISONS OF CROSS SECTION SURVEYS BY UC DAVIS, DWR, TETRATECH, SHN, AND FRWTF

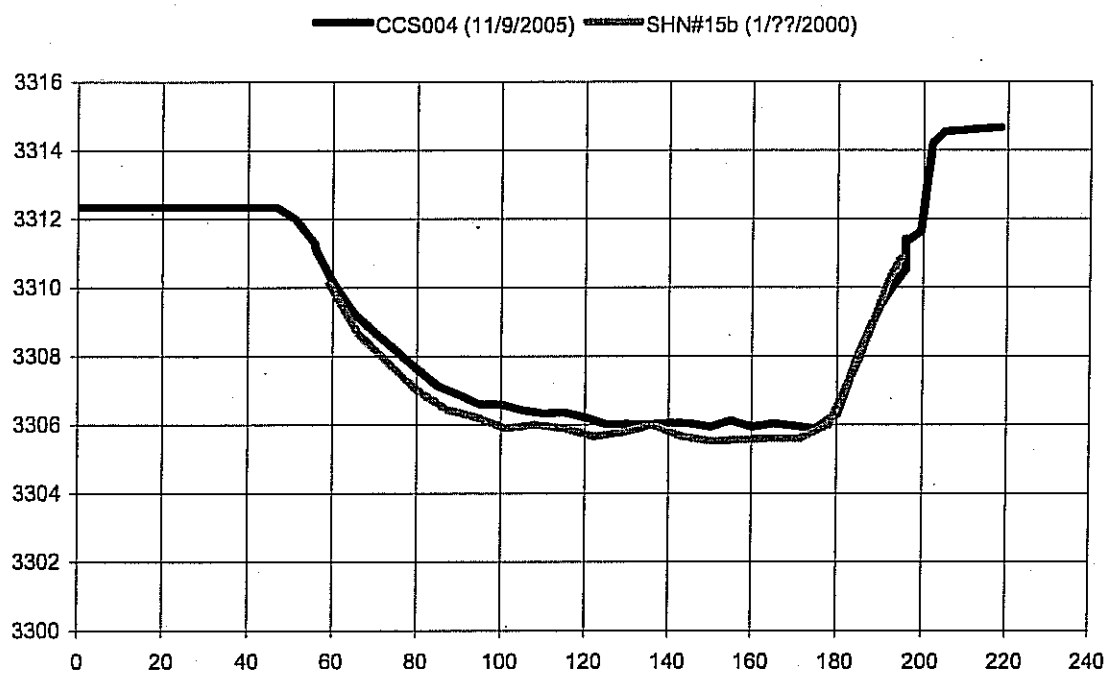
Cross Section Survey Comparison between SHN#9 and CCS003



Cross section CCS003 experienced a net loss of 59.3 ft^2 of sediment in the five years between the UC Davis survey of 9 November 2005 and the SHN survey of January 2000 (calculated using a water surface elevation of 3309 ft). Scouring of this channel was apparent on the left bank and bottom of the channel. All of the sediment deposition was confined to the right bank.

APPENDIX VII: COMPARISONS OF CROSS SECTION SURVEYS BY UC DAVIS DWR, TETRATECH, SHN, AND FRWTF

Cross Section Survey Comparison between SHN#15b and CCS004



Cross section CCS004 showed a net sediment deposition of 45.7 ft^2 during the five years between the SHN survey in January of 2000 and the UC Davis survey on 9 November 2005 (calculated using a water surface elevation of 3310 ft). This small but consistent accumulation of sediment occurred on the left bank and continued across the bottom of the channel. There was no change to the right bank of the channel.

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